NAVIGANT

ANALYSIS TO UPDATE ENERGY EFFICIENCY POTENTIAL, GOALS, AND TARGETS FOR 2013 AND BEYOND

TRACK 1 STATEWIDE INVESTOR OWNED UTILITY ENERGY EFFICIENCY POTENTIAL STUDY

Prepared for:
California Public Utilities Commission

Navigant Consulting, Inc.
1990 North California Blvd., Suite 700
Walnut Creek, CA 94596

925.930.2700
www.navigant.com

May 8, 2012

NAVIGANT

Table of Contents

NAVIGANT

List of Figures

List of Tables

Sources of the 2013-14 Electric and Gas Energy Efficiency Goals

The adopted 2013-2014 electric and gas goals are based on this potential study and version 1.1 of the accompanying Analytica model[1]. Based on party comments on the proposed decision, the potential study report and model released on March 20, 2012 were revised to update certain measure assumptions, gas potential and interactive effects, further described below.

Source of 2013-2014 Electric and Gas Goals in Report

IOU Program Targets are based on the 2013 and 2014 incremental market potential for electricity, peak savings and gas, listed in Table 1. Codes and Standards Advocacy Targets for 2013 and 2014 are based on the net C&S estimated savings, listed in Table 29.

Accessing source data in IOU Potential Model

The source data, inputs and calculations can be viewed in the Analytica model, which is available on the CPUC website. The model can be viewed with the free player, which can be downloaded from the Analytica website.[2]

Source of Electric Goals in Model

The detailed data for the Electric Goals can be found in version 1.1 of the Model. The data can be viewed from the output *Key Components of Incremental Market Potential plus C&S* found on the main user interface. This is located in the "Outputs" section under "Statewide and IOU Specific Results."

To map the PD table labels to the Model legend, use the following:

» *IOU Program Targets = IOU Measures (HIM, MOI, Secondary, LI) + IOU Measures (ET) + IOU Measures (Usage-Based Behavior)*

» *Codes and Standards Advocacy = Codes and Standards*

Source of Gas Goals in Model

The data for gas goals can be viewed from the output *Key Components of Incremental Market Potential plus C&S* found on the main user interface of the model in the "Outputs" section under "Statewide and IOU Specific Results". This figure can be used to display results *with* or *without* gas interactive effects. As a default, the model runs *with* interactive effects. To view results *without* interactive effects set the input toggle "Gas Interactive Savings from Elec" to "No", run the model again, and open the output node again. Both scenarios (*with* and *without*) must be run separately; the model will not calculate them simultaneously.

Similar to the electric goals, to map the PD table labels to the Model legend, use the following:

» *IOU Program Targets = IOU Measures (HIM, MOI, Secondary, LI) + IOU Measures (ET) + IOU Measures (Usage-Based Behavior)*

» *Codes and Standards Advocacy = Codes & Standards*

[1] 2011 IOU Service Territory EE Potential Study – Analytica Model V1.1

[2] The player is available at http://www.lumina.com/products/analytica-editions/free-player/

1 Executive Summary

1.1 Introduction and Background

This potential study is Track one of the Analysis to Update Potential Goals and Targets for 2013 and beyond, developed for the California Public Utilities Commission (CPUC or 'Commission'). The purpose of this potential study is to support the Commission in setting goals for the Investor Owned Utilities' (IOU) energy efficiency (EE) program portfolios in the coming years, by determining how much energy savings potential will be available in the coming decade, and from what sources. It represents an update to the previous potential study prepared by Itron in 2008[3] (referred to as the '2008 potential study') by revising the findings to some of key questions addressed in the 2008 potential study:

- What is the remaining EE potential for from 2013 through 2024 that the Commission can anticipate that customers will be willing and able to adopt through voluntary programs?
- How is the potential for EE distributed across market sectors and end uses?

As the first track of the Potential, Goals & Targets study, this report (referred to as the '2011 potential study') presents a comprehensive and detailed view of the technical, economic, and market potential for energy efficiency for the four California IOUs[4]. The second track of the Potential, Goals and Targets Study will conduct an analysis of the policy and market mechanisms that deliver these energy savings, running multiple scenarios to determine the most cost effective combination of initiatives to deliver the greatest amount of savings. These analyses will support the Commission in establishing goals and targets for the IOUs in future portfolio cycles.

The 2011 potential study models potential energy savings for the following sources:

- **Existing IOU incentive based programs** are calculated based on the savings for all measures above the Title 20/24 code and federal standards baseline that have been included in current or past IOU incentive programs. The potential study updates these measures using the results of the 2006-08 program evaluations[5].
- **Emerging Technologies (ET**) are measures that have not been included in previous incentive programs or are included on a limited or pilot basis. These are measures that are technically viable and become a component of market potential when various factors, such as measure cost, field performance, and potential market acceptance indicate that a technology can be successfully implemented through various program delivery mechanisms
- **Behavioral Program Savings** are results of "usage-based behavior," such as turning off lights, unplugging electronics and chargers, programming thermostats, and improving the efficiency of equipment through modified maintenance practices. Behavior programs provide targeted marketing and education to customers that support these activities.
- **Low Income Programs** that are authorized by PU Codes 382 and 890 provide energy efficiency upgrades for qualifying low-income customers. The energy savings and cost effectiveness impacts for these programs differ from other types of EE programs.

---

[3] *"California Energy Efficiency Potential Study"* ITRON (2008); (www.calmac.org, CALMAC ID: PGE0264.01)
[4] Pacific Gas & Electric, Southern California Edison, Southern California Gas, and San Diego Gas & Electric
[5] Available at CALifornia Measurement Advisory Council (CALMAC) at http://www.calmac.org/

» **Agricultural Sector Potential** represents a source of EE potential that has not been previously estimated prior to the 2011 potential study and accounts for approximately 4% of statewide IOU territory market potential in 2013.

» **Codes and Standards (C&S) Programs** provide technical support and advocacy for the adoption of energy efficiency measures into California Title 20 & 24 building codes and federal appliance standards. The IOUs receive credit toward their goals for the C&S savings that can be attributed to their code related program activities.

Navigant Consulting, Inc.'s (Navigant's), approach to the 2011 potential study builds upon the standard bottom-up modeling methodology that has been used in many states and is consistent with the CPUC's past goal-setting approach. The bottom up methodology identifies all energy efficiency measures—possible changes that can be made to a building, equipment or process that could saving energy—and calculates the total possible energy savings available above the baseline. The baseline is established by the maximum energy use permitted by building code or appliance standards.

Consistent with the 2008 potential study, the 2011 potential study provides forecasts energy efficiency potential based on three levels of screens, as illustrated in Figure 1 below.

1. Technical Potential Analysis: Technical potential is defined as the amount of energy savings that would be possible if all technically applicable and feasible opportunities to improve energy efficiency were taken, including retrofit measures, replace-on-burnout measures, and new construction measures[6].
2. Economic Potential Analysis: Using the results of the technical potential analysis, the economic potential is calculated as the total energy efficiency potential available when limited to only cost-effective measures[7]. All components of economic potential are a subset of technical potential[8].
3. Market Potential Analysis: The final output of the potential study is a market potential analysis which is defined as the energy efficiency savings that could be expected to occur in response to specific levels of program funding and customer participation based on assumptions about market influences and barriers. All components of market potential are a subset of economic potential. Some studies also refer to this as "Maximum Achievable Potential"[9].

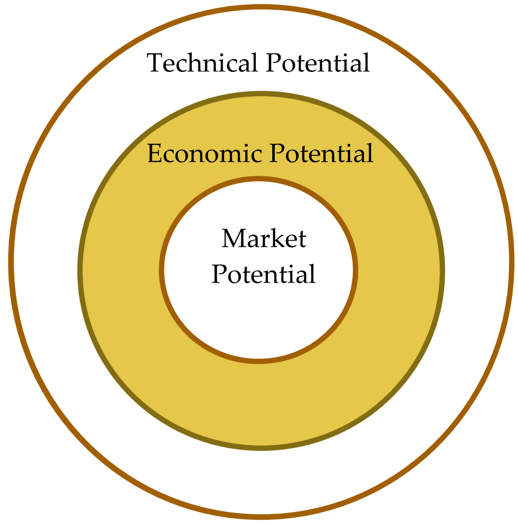
[6] For reference, technical potential typically ranges between 15 to 25% of annual sales depending on the market sector and market baseline conditions.

[7] As discussed in Section 3.6, the default cost effectiveness threshold for economic potential is that a measure must a total resource cost test value of 0.80 or greater.

[8] For reference, economic potential typically ranges between 13% to 23% of annual market sector sales depending on the amount of technical potential available, the cost test used to screen for economic feasibility, the value of avoided energy costs to an energy provider and the cost of energy to consumers.

[9] For reference, incremental annual market potential typically ranges between 0.5% to 2.5% of annual market sector sales depending on the amount of economic potential and customer acceptance and barriers to implementing EE measures and initiatives.

Figure 1. Diagram of Types of Energy Efficiency Potential



Using the 2011 update to the Database of Energy Efficiency Resources (DEER), which incorporated the results of the 2006-2008 program evaluations, the 2011 potential study incorporated the latest estimates of baseline end-use equipment ownership and load profiles, energy efficiency measure costs, savings, and saturation levels across the service territories of California's four IOUs. The 2011 potential study has been developed to be consistent with the mid case scenario of the 2008 potential study[10]. The mid-case scenario represented the most likely scenario or economic and market factors.

This report is limited to a view of EE potential based on a single set of scenario assumptions, in order to support the goals setting process for the 2013-14 transition period. The subsequent goals study, referred to as track two of the 'Analysis to Update Potential Goals and Targets for 2013 and Beyond', which will be completed as Track two of the Potential, Goals and Targets Analysis, will develop scenarios and examine additional delivery mechanisms such as the Strategic Plan activities in order to identify new sources of EE potential for the period beginning in 2015.

1.2 *Findings*

The technical and economic potential, illustrated in Figure 2 below, represents the trend in the total energy savings available each year that are above the baseline of the Title 20/24 codes and federal appliance standards. The technical potential is an aggregation of all energy savings from all measures that technically feasible in each sector, while the economic potential is limits the potential to only measures that are cost effective based on the total resource cost test[11].

The 2011 potential study found a leveling off of available technical and economic potential over the next decade. Figure 2 shows the difference in technical and economic energy potential (GWh) between the 2008 and 2011 potential studies, for the period from 2007 through 2016,[12] and also the 2011 forecast

---

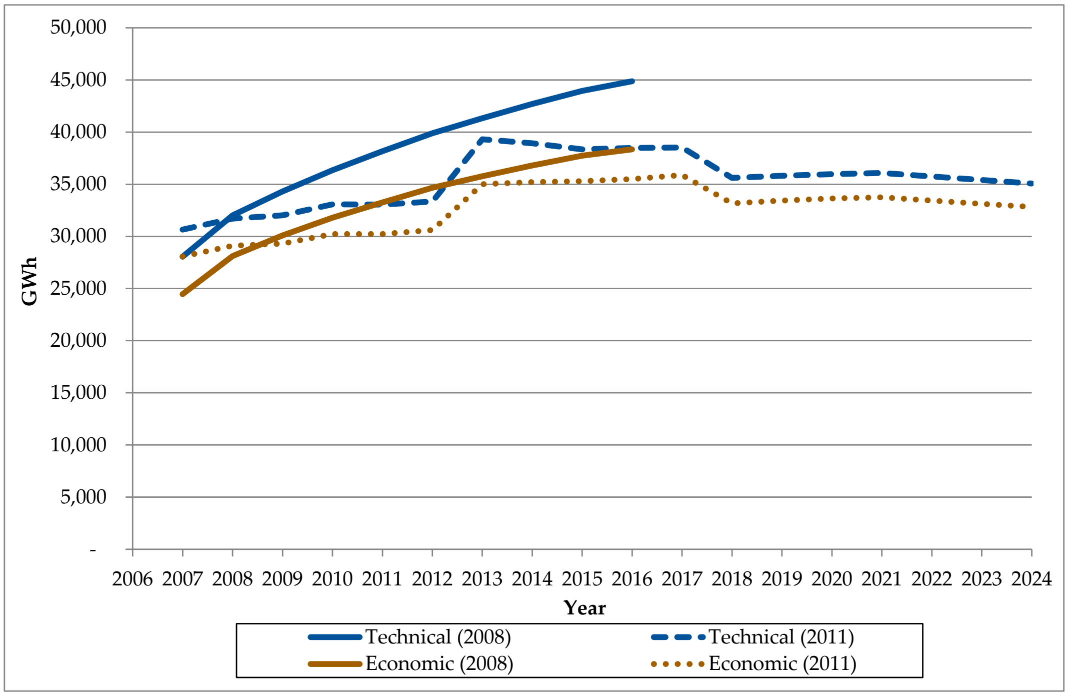
[10] The 2008 potential study provided 10 scenarios, one of which was based on the mid case for the 2007-08 IEPR forecast.

[11] The Total Resource Cost Test (TRC) is defined in the Energy Efficiency Standard Practice Manual, p. 18, which can be found at http://www.energy.ca.gov/greenbuilding/documents/background/07-J_CPUC_STANDARD_PRACTICE_MANUAL.PDF

[12] The period 2007 through 2016 was chosen as this was the time frame over which the forecasts for technical and economic potential could be compared between the 2008 and 2011 studies. The 2008 potential study forecast horizon was 2026, while the 2011 potential study horizon was 2024.

extending to 2024. Both technical and economic potential forecasts are adjusted slightly downward in all comparison years after 2008. The forecast potential in Figure 2 is a cumulative value showing increases in some years and decreases in others. The fluctuations are primarily due to the implementation of changes in codes and standards (C&S) that shift EE savings out of EE potential and into codes and standards savings forecasts, as well as the introduction of emerging technologies that become viable at different times. The 2011 report ended its forecast in 2024, with technical and economic potential in that year estimated at approximately 35,000 and 33,000[13], respectively, compared with the 2008 potential study, which estimated technical and economic potential in the year 2026 at 50,610 and 42,278 GWh respectively.

Figure 2. Technical and Economic Energy Potential 2007–2024 (GWh)



The incremental market potential represents the amount of additional new energy savings forecasted to be delivered by IOU programs each year based on past program and market evaluations and the most recent planning assumptions and forecasts. Market potential is the final screen on potential and is intended to forecast what customers will likely install given incentive levels and historic implementation rates. Market potential is also known as "maximum achievable" potential, and is the basis for setting IOU goals.

Figure 3 shows the forecast of incremental annual market potential from 2010 through 2024 by measure type. During the period from 2010 through 2017 the 2011 potential study has found a generally consistent shift in incremental market potential between what can be installed through voluntary energy efficiency programs and what will be installed through code. Meanwhile, emerging technologies and usage based behavioral initiatives will become increasingly important, as will be further discussed in the following section. The market potential for C&S savings in Figure 4 represents the savings that are forecast to be attributable to IOU C&S advocacy efforts. These savings are technically not EE potential above the baseline, but rather, the estimated savings from Title 20/24 code and federal standard

[13] The estimates of technical and economic potential for the 2011 potential study shown in Figure 2 do not include the impacts of codes and standards because codes and standards are not included in the 2008 potential study.

implementation that can be attributed to the IOU C&S program activities. The IOU attributable C&S savings are necessary to quantify in order to set the IOUs goals for the next portfolio cycle, and includes measures that that have shifted from IOU programs into code in recent years, or are planned to shift based on pending code changes.

Figure 3. Incremental Annual Market Potential Impacts 2010–2024 by Measure Type Category

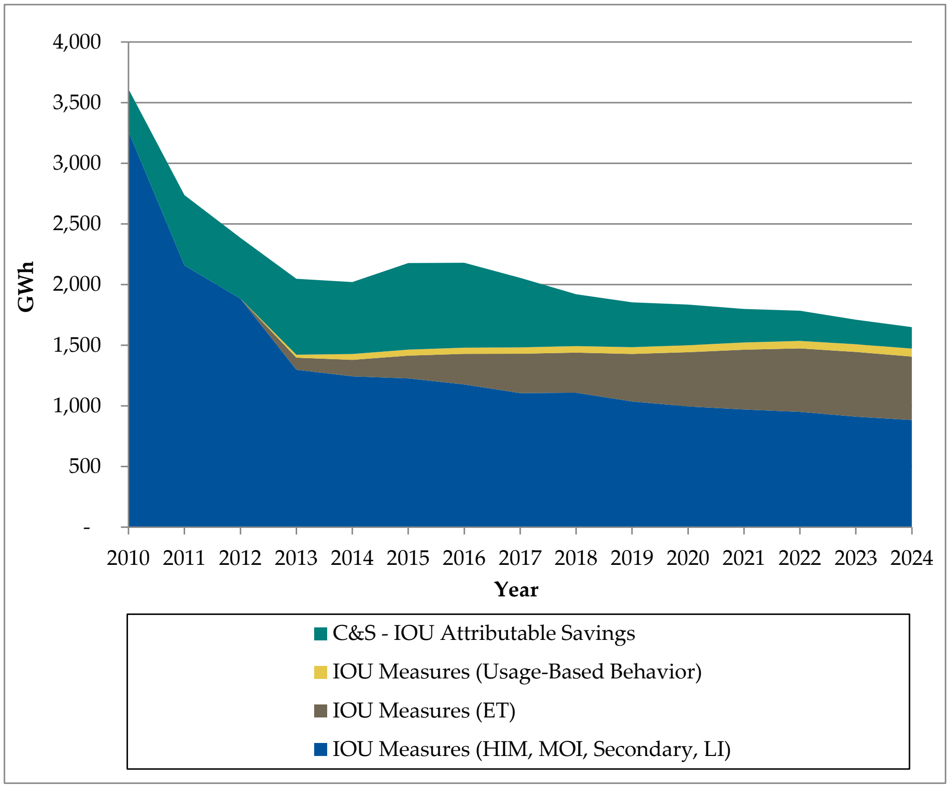


Table 1 details the incremental market potential for each IOU service territory. Incremental market potential includes all IOU measure classes (HIM, MOI, ET, Secondary, LI, ET, and Usage-based Behavior).

Table 1. Incremental Market Potential Results

Incremental Market Potential	IOU	2013	2014	2015	2016	2017	2018	2019	…	2024
Electric Savings (GWh/yr)	PG&E	599	593	599	609	596	583	587	…	629
	SCE	660	678	712	728	744	752	743	…	705
	SDG&E	162	156	152	143	142	158	153	…	138
	Total	**1,422**	**1,427**	**1,464**	**1,480**	**1,482**	**1,493**	**1,484**	…	**1,472**
Peak Savings (MW/yr)	PG&E	114	100	100	101	97	99	100	…	107
	SCE	149	144	148	147	146	147	141	…	129
	SDG&E	36	33	31	29	28	33	31	…	25
	Total	**300**	**277**	**279**	**278**	**272**	**279**	**272**	…	**261**
Gas Savings Including Interactive Effects (MMMT/yr)	PG&E	21.0	20.3	20.0	21.1	21.0	21.5	22.5	…	26.9
	SCG	24.0	22.3	21.4	21.0	20.9	21.3	21.8	…	25.2
	SDG&E	2.2	2.1	2.2	2.4	2.7	3.1	3.3	…	4.8
	Total	**47.2**	**44.8**	**43.5**	**44.5**	**44.6**	**45.9**	**47.6**	…	**56.9**

The following factors have played a key role in the changes in energy efficiency potential shown in Figure 2 and Figure 3 and are further discussed in the referenced sections.

1. **Changes in Underlying Savings Assumptions for Energy Efficiency Measures:** The 2006-2008 evaluation results, as well as several other recent studies, have led to downward adjustments to savings assumptions for many energy efficiency measures and is further discussed in Section 4.

2. **Changes in Codes and Standards:** The adoption of new Title 24 Codes and Federal appliance standards has led to the uptake of several EE measures that were previously components of the technical potential. As these codes go into effect, they become the baseline, reducing the technical and economic potential that can be achieved by traditional utility-incentive-driven programs. The application of codes and standards is addressed in Section 4.7.

3. **Potential for Emerging Technologies:** As emerging technologies become technically and economically viable, they cause an upward shift in technical, economic, and market potential. Emerging technologies are addressed in Section 4.4.

4. **Potential for Usage-Based Behavioral Impacts:** Estimates of the potential for usage-based behavioral initiatives based on recent studies have been included in potential estimates and the method and select research topics are further addressed in Section 4.5.

5. **Potential for the Agricultural Market Sector:** Section 9 of the study includes an estimate of technical, economic, and market potential for the agricultural sector. Potential in the agricultural sectors constitutes about 4% of IOU service territory market potential.

6. **Decrease in Forecasted Loads:** The CEC IEPR demand forecast has found a significant decline in the forecasted load from 2008 to 2011 due to the economic downturn, which is further addressed in Appendix M: EERAM Model Algorithm and Input Details.

7. **Changes in the Modeling Methodology:** The 2008 potential study was developed by Itron using their ASSET model[14]. While Navigant has used a consistent approach, there are variations on

[14] The ASSET model was developed by Regional Economic Research, Inc. (RER). RER was acquired by Itron in 2003. California Energy Efficiency Potential Study, Submitted to Pacific Gas & Electric Company, Submitted by:

certain calculations in the Energy Efficiency Resource Assessment Model (EERAM) model, in particular in the approach to calculating low-income energy efficiency (LIEE) and appliance recycling as discussed in Section 4 and Appendix M: EERAM Model Algorithm and Input Details 4.

1.2.1 Changes in Underlying Savings Assumptions for Energy Efficiency Measures

The results of the 2006-2008 evaluation report found discrepancies between the ex-ante planning assumptions on which the IOUs' reported savings were based and the results of the ex-post impact studies. One of the primary tasks of the 2011 potential study was to update the savings assumptions with ex post savings data, using the Standard Program Tracking Database (SPTdb). The SPTdb provides details on measure-level ex ante and ex post savings for the 2006 through 2009 program years. This data was used to calibrate the potential model such that the model outputs reflected the most current ex-post evaluation data.

Particular attention was paid to the 2006–2008 Energy Division's Evaluation, Measurement and Verification (EM&V) reports because those evaluation projects included many of the detailed engineering studies that changed the underlying measure assumptions used in the 2011 potential study. For example, Table 2 provides a comparison of ex ante and ex post gross savings values for the top five measures that accounted for 65% of reported first year gross savings for the entire IOU EE program portfolio as presented in the 2006–2008 SPTdb dataset. The savings associated with this basket of five measures were reduced by 10% to 60%, with the largest savings reduction being applied to CFL lamps that accounted for over 50% reported ex-ante savings estimates. The aggregate impact on the dataset to which the Navigant model was calibrated was approximately a 50% reduction from the ex-ante reported gross and net savings.

The 2008 potential study was completed before the 2006-2008 EM&V results were available and so the 2008 potential study did not incorporate the majority of the 2006-2008 evaluation data. The 2011 potential study is calibrated to the to the 2006-2008 EM&V results and so the 2011 potential study is calibrated to measure savings values that are generally lower than the values used in the 2008 potential study.

Table 2. Percent Reduction in Savings between Ex Ante and Ex Post Results

Measure	Percent of Portfolio Ex Ante Gross Savings	Percent Reduction in Savings (Gross Ex Ante to Ex Post)
Interior Screw Lighting (CFLs)	51%	-60%
Linear Fluorescent	5%	-21%
Recycle Refrigerator	4%	-37%
Process - Unknown	3%	-34%
Lighting - Unknown	2%	-10%

The research team made significant revisions to the potential estimates for many individual measures; CFLs and refrigerator recycling are particularly important. These measures represented the first and third highest sources of potential for the residential sector in the 2008 potential study, respectively, with

CFLs playing an important role in the commercial sector as well. Savings potential from CFL is impacted primarily by the following factors:

1. Revised saturation that indicated most remaining potential is in specialty CFLs based on recent evaluation data[15]
2. Reduction of average CFL operating hours as lower use sockets were found to account for a higher percent of installations. Various evaluations have found that when CFL lamps were initially introduced into the market they were being installed in light fixtures with long run hours, such as kitchen applications, because the energy savings would be greatest in these areas. As CFL lamps have continued to penetrate the market they are increasingly being installed into lower use sockets such as closets. The net effect of this trend is to lower the annual average operating hour estimate for the population of installed CFLs.

1.2.2 Changes in Codes and Standards

There have been a number of energy efficiency measures adopted into codes and standards since 2008. The California Energy Commission (CEC) most recently updated the state appliance standards (Title 20) in 2011 and building energy efficiency code (Title 24) in 2008. Federal appliance efficiency standards were most recently updated and adopted though legislation and U.S. Department of Energy (DOE) rulemakings, ongoing through 2011. C&S analysis in this study is based on adopted standards or nearly adopted standards, so the study reflects actual C&S impacts for both CEC and federal standards. The analysis was constrained to codes that have changed since the 2008 potential study and codes that are pending and for which changes in measure baseline can be predicted with some certainty. Additional codes changes will certainly take place over the 2013–2024 time line of this study; however, these "aspirational" codes were not included in this analysis.

As will be discussed in Section 4.7, the adoption of new codes and standards increases the energy use baseline and decreases technical, economic, and market potential achievable by traditional utility incentive-driven programs, as these technologies become part of the new baseline. Section 4.7 also discusses how these codes were reviewed; these estimates of technical potential are based on recently or nearly adopted codes and standards, and therefore exclude any impact from other C&S changes that will likely occur over the 2013 through 2024 time frame of this study.

Lighting potential has been particularly impacted by the adoption of new codes and standards. Federal lighting standards have been implemented through the Energy Independence and Security Act (EISA), which requires manufacturers to improve the performance of incandescent lamps starting in January 2012. EISA requires that for the same lumen output, energy use of all incandescent lamps would reduce by 25%.[16] The Huffman Bill[17] (which is specific to California) phases in from 2009 through 2014 and raises the residential lighting baseline for future years, which in turn reduces new potential from IOU programs. New savings for non-specialty CFLs covered by the Huffman Bill are zero starting at 2018.

---

[15] *"Residential Lighting: Shedding Light on the Remaining Savings Potential in California," IEPEC 2011:* Kathleen Gaffney, Tyler Mahone, and Alissa Johnson (KEMA Inc.).

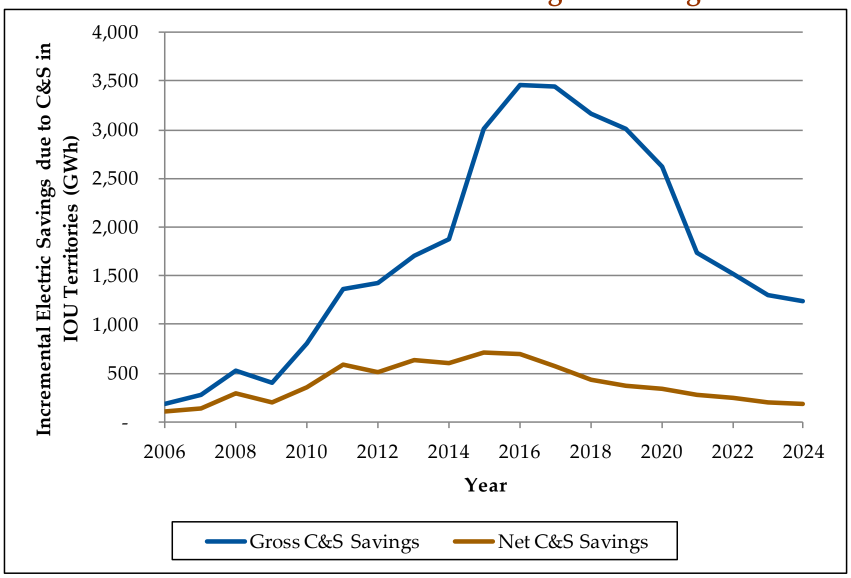
[16] http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/lighting_legislation_fact_sheet_03_13_08.pdf

[17] Assembly Bill No. 1109, Approved by the California Governor on October 12, 2007 and filed with the Secretary of State October 12, 2007. This bill tasks the California Energy Commission with reducing lighting energy usage in indoor residences and state facilities by no less than 50%, by 2018, as well as requires a 25% reduction in commercial facilities by that same date. http://www.climatechange.ca.gov/publications/legislation/ab_1109_bill_20071012_chaptered.pdf

Savings from specialty CFLs[18] remains a viable source of technical, economic, and market potential for the foreseeable future because at the time of this study they are not yet subject to any pending or developing codes or standard.

The study looked at both annual gross and net C&S program savings for each IOU for different groups of standards. Gross C&S code savings are defined in this report as all incremental savings that result from code within an IOU service territory. Net savings are defined here as the incremental energy savings attributed to IOU C&S programs and advocacy from the installation of measures that comply with energy efficiency standards each year. Net savings account for all C&S energy savings factors, including compliance rate, naturally occurring market adoption (NOMAD), and IOU attribution. Figure 4 provides an estimate of the incremental annual gross and net C&S program savings for all IOUs (GWh) from 2006 through 2024. Net savings are considered when estimating annual incremental market potential.

Figure 4. Incremental Annual Gross and Net C&S Program Savings for all IOUs (GWh)



1.2.3 Potential for Emerging Technologies

Emerging technologies provide new sources of EE potential that were not available when the 2008 potential study was conducted. To assess the potential of emerging technologies, Navigant examined 800 possible emerging technologies and identified and assessed 90 technologies as "high potential." The screening process and subsequent reviews were conducted at a high level because of project schedule constraints, available resources, and inadequate data that often impede the analysis of emerging technologies. This list was ultimately narrowed down to 23 of the highest potential technology types (encompassing 67 individual measures in total) based on several metrics discussed in Section 4.4. These remaining measures were modeled in the study.

Navigant assumed that emerging technologies would become viable candidates for technical potential if they met selected criteria discussed in Section 4.4. In summary, the screening criteria indicate at what point a technology's performance, market application, and costs are viable such that a technology could enter the market for early adopters. It's important to note that the full value of the technical potential for an emerging technology becomes available in the year the technology meets the screening criteria, though market potential develops more slowly due to barriers such as low initial acceptance or costs that

[18] Specialty CFLs are primarily considered to be globes, such as vanity lights, or floodlights.

are typically higher than more mature technologies that might be competing for the same application. Emerging technologies represent a key source of new technical potential, as Figure 5 illustrates.

Figure 5. Key Components of Technical Potential Including Emerging Technologies

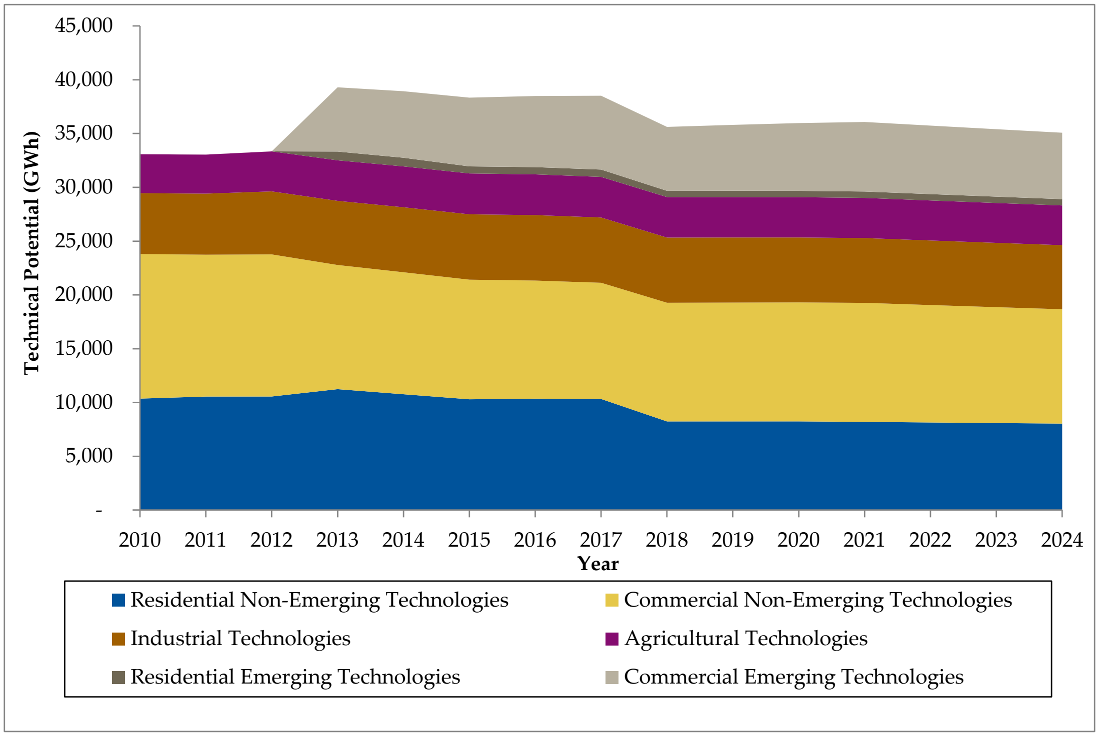
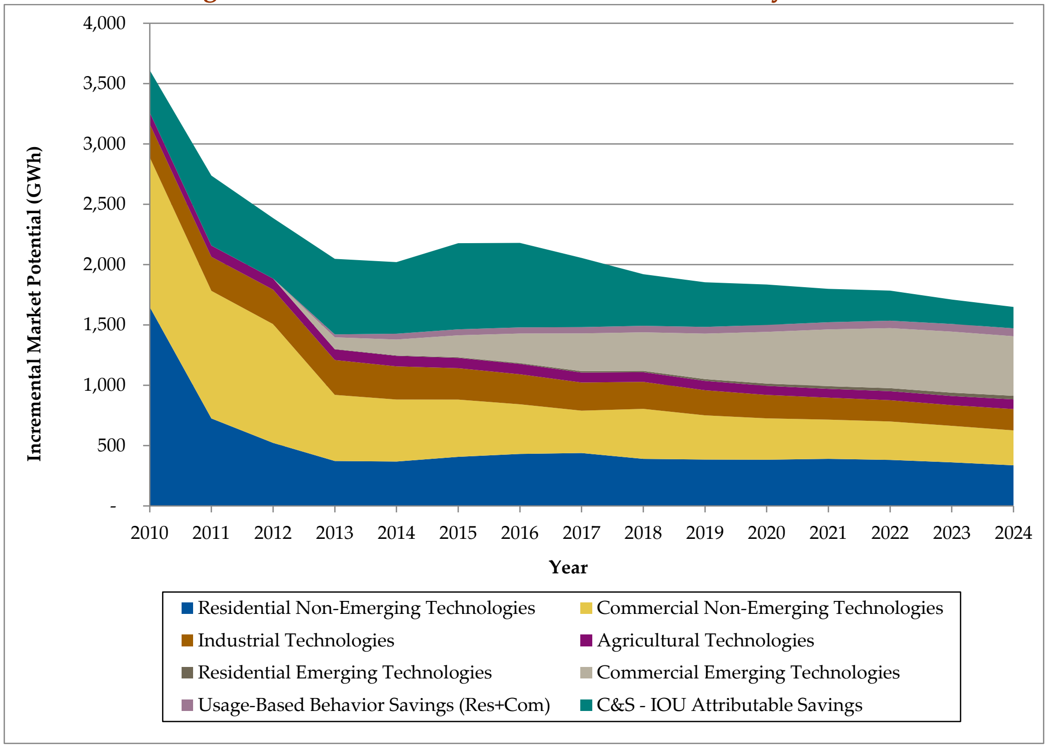


Figure 6 shows the impact of emerging technologies for the residential and commercial sectors on the incremental market potential forecast. Beginning around 2013, roughly 6,700 GWh of technical potential from emerging technologies should become available, with approximately 88% (5,900 GWh) of this potential occurring in the commercial market. Market potential represents a more modest value in 2013 at 100 GWh. Emerging technologies for the industrial, agricultural, and mining sectors were not addressed in this study but are identified as a critical research recommendation. Additional emerging technologies in all sectors will certainly become viable over the study time line and will be an important topic in future updates.

Figure 6. Incremental Annual Market Potential by Sector



1.2.4 Potential for Usage Based Behavioral Impacts

The 2011 potential study provides estimates of savings potential for residential and commercial behavioral initiatives, which were not included in the 2008 potential study. For this study Navigant broadly characterized the savings resulting from behavior-based initiatives as equipment-based (e.g., replacing light bulbs) and usage-based (e.g., turning lights off) because the persistence and long-term technical potentials of these two types of savings were expected to vary considerably. Equipment-based behavioral impacts are included implicitly in the equipment models of the analysis, as incremental effects to the awareness of measures and willingness to adopt them. Usage-based behavioral impacts are included as additional models.

While behavior programs have demonstrated significant levels of savings, impact studies have not provided the level of granularity that is necessary for proper representation in a long-term potentials study.

- The most precisely known impacts from residential behavior programs are of mailed home energy reports, where experimental design and billing analyses are used to identify whole-house impacts during and after program exposure. Average electric savings per participant are typically estimated at around 2% of household consumption. However, this approach provides no insight as to *which* actions are leading to these savings (equipment vs. usage), and therefore no indication of the expected long-term effects of these programs.
- In the commercial sector, the most rigorous impact estimates are from building operator certification courses, which train building operators on maintenance practices and equipment measures for saving energy. Savings estimates are based on participant interviews and engineering analysis and have typically been 2% to 3% of building energy consumption, with approximately 10% of these savings coming from usage-based actions (i.e., changes to operations and maintenance practices). Much less is known about the impacts of other commercial sector behavior programs.

Furthermore, the potential participation levels in these programs are unclear. Specifically in the residential sector, many customers would be excluded from this potential, such as households on medical rates, households that have recently moved (no basis for feedback), and households withheld from the program to provide a control group for evaluation efforts. Additionally, the persistence of savings beyond a couple of years is unknown, and thus the effective rates of reparticipation are unknown. For commercial programs, it is unknown what percentage of commercial floor space could feasibly be reached by programs each year.

Assumptions used in the model were ultimately based on a combination of secondary research[19] and discussions with behavioral program administrators at the California IOUs. Target penetration levels were set relatively low to reflect uncertainties in long-term impacts and the IOUs' need to learn more about the impacts of these programs through gradual rollout and evaluation of programs. Because of the conservative penetration assumptions, the modeled savings potential from behavior are low relative to total sector savings potential. These savings are summarized in Table 3.

Table 3. Forecast Behavioral Technical Potential (GWh)

Category	2013	2024
Commercial, Usage	1	8
Commercial, Equipment*	11	76
Commercial, Total (Usage and Equipment)	***12***	***84***
Residential, Usage	23	57
Residential, Equipment*	11	28
Residential, Total (Usage and Equipment)	***34***	***86***

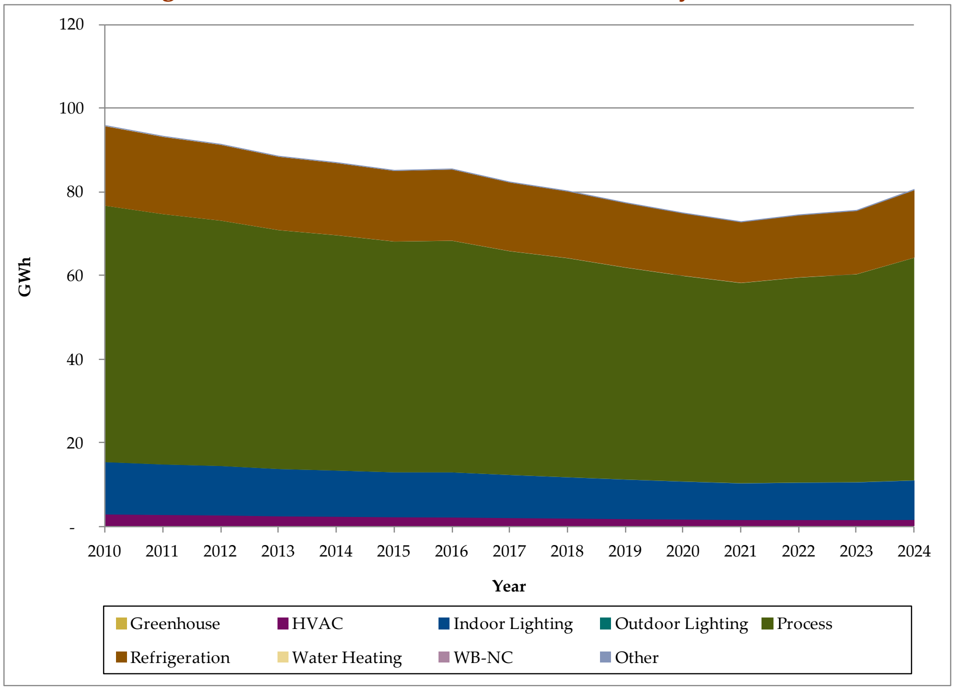
**Equipment potential is a portion of total programmatic equipment potential.*

1.2.5 Potential for the Agricultural Market Sector

The 2011 potential study provides the first estimate of energy efficiency potential for the agricultural sector in the IOU service territories. This estimate was completed in participation with the 2010-2012 Statewide Agricultural Market Characterization & Energy Efficiency Potential Study. This model includes limited primary data collected through study and literature reviews conducted by the Navigant team and estimates market potential is generally less than one percent of combined IOU agricultural market sales in any year of the study time frame. Annual incremental market potential in 2013 is estimated at approximately 86 GWh, about 4% of total estimated incremental market potential for that year, with the majority of savings in the process measure category, as shown in Figure 7.

[19] See Appendix C

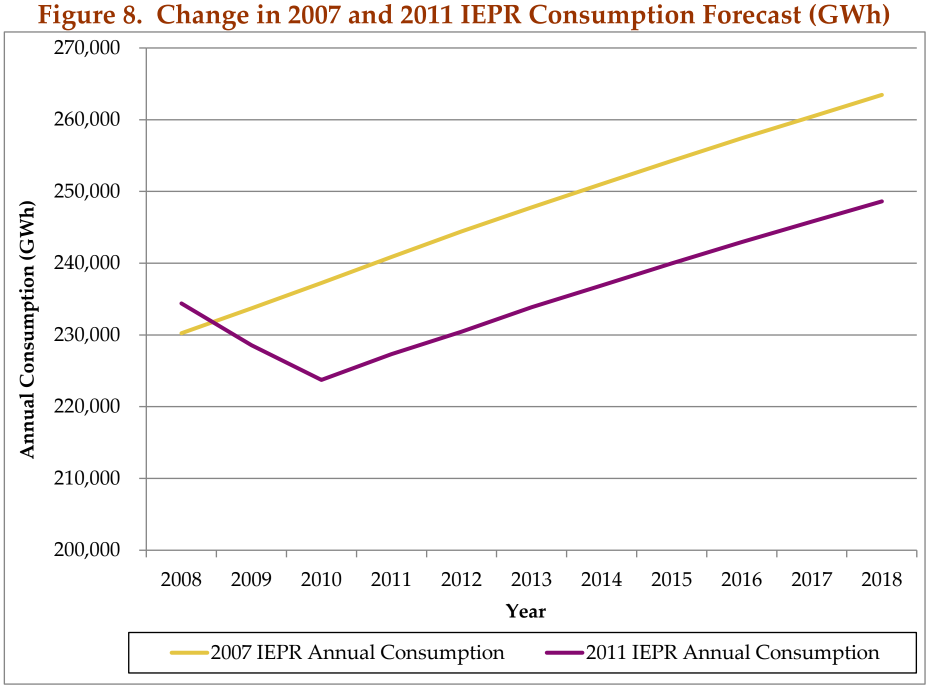
Figure 7. California Agricultural Incremental Market Potential by End Use for 2010-2024 (GWh)



1.2.6 Changes in Forecasted Loads

Due to changes in economic conditions since 2008, the 2011 IEPR has forecasted a 5.5% decrease in total consumption. However, loads are forecasted to increase at about 1.3% per year on average. Figure 8 shows the projected total IOU GWh consumption forecast for 2008 through 2018 for the 2007 and 2011 IEPR. This reduction in load impacts potential forecasts for both the existing and new construction markets.

Figure 8. Change in 2007 and 2011 IEPR Consumption Forecast (GWh)



1.3 Recommendations

While the 2011 potential study provides an update using best available data and accepted methodologies, Navigant has identified several areas that could improve the assessment of market potential, providing a more complete and accurate picture of where the opportunities are to maximize energy savings. The following recommendations are offered with the intention of increasing the comprehensiveness and accuracy of the technical potential provided by this study, and examining market potential may be expanded to more closely approximate economic potential.

1.3.1 Align Cost Benefit Screening with Strategic Plan Objectives

This study and all previous studies use a fairly simple method to screen measures for economic and market potential. Economic potential screens all measures based on a fixed total resource cost test (TRC)[20] threshold, which in this study was set at 0.80[21]. Market potential is estimated based on expectations that a consumer will take action based on a financial incentive, typically a rebate. Using a fixed TRC threshold presents investment criteria that assume all components of a potential study or portfolio present the same risk and reward profile and can be judged with the same metric.

This one-size-fits-all screening approach is inconsistent with the Strategic Plan[22] objective to provide a platform to identify new collaborative initiatives across market sectors and cross-cutting areas, or to help accelerate the improvement of cost-effective EE technologies and program delivery mechanisms over time. This screening approach cannot value these market development initiatives or recognize various nuances, such as, for example, the recognition that technical assistance could yield increased adoption in lieu of rebates in some markets. In order to begin process of differentiating energy efficiency measures such that they can be valued based on their relation to the market Navigant categorized the energy efficiency measures in this study as high impact, secondary, measures on interest, and emerging technologies. These measure categories can also be related to stages of market adoption as defined through the Bass diffusion theory[23]. Subsequent potential study updates may consider this paradigm so that goals, targets, and resulting program interventions can better complement a measure's market adoption phase. For example, the economic screening criteria for emerging technologies could be very different from the criteria used to assess the potential for measures for which code adoption is imminent. This may result in program design intended to more quickly bring new measures to market, while minimizing the cost of promoting mature devices and technologies. Table 4 presents an alternative approach to categorizing measures evaluated in the 2011 potential study using Rogers' technology adoption life-cycle model,[24] including a relationship between the measure category, Bass segment

[20] The Total Resource Cost Test (TRC) is defined in the Energy Efficiency Standard Practice Manual, p. 18, which can be found at http://www.energy.ca.gov/greenbuilding/documents/background/07-J_CPUC_STANDARD_PRACTICE_MANUAL.PDF

[21] Similar to the 2008 potential study, the TRC restriction implemented in this analysis was set at 0.85 to reflect the fact that EERAM implements the TRC restriction at the measure level, while the actual cost-effectiveness rule is at the portfolio level. A TRC value less than 1.0 is used to provide flexibility to incentivize measures that are not yet cost-effective and to enable the inclusion of them to install nearly cost-effective measures included in bundled measures like whole-house initiatives.

[22] California Long Term Energy Efficiency Strategic Plan, California Public Utilities Commission, September 2008

[23] Frank Bass, "A new product growth model for consumer durables," 1969, Management Science 15 (5): pp. 215–227.

[24] Rogers' technology adoption life-cycle model assumes adopters of any new technology can be categorized as innovators (2.5% of the population), early adopters (13.5%), early majority (34%), late majority (34%) or laggards (16%), based on a bell curve. Each adopter's willingness and ability to adopt a technology depends on their awareness, interest, evaluation, trial, and adoption. For additional information see: Rogers, E. M., *Diffusion of innovations (5th ed.)*, New York: Free Press, 2003.

definition, and phase of code development. This might serve as one of several frameworks within which a business case can be developed to more efficiently match resources, markets, and delivery mechanisms for energy efficiency products and services identified in the Strategic Plan.

Table 4. Relationship between Measure Categories and Market Adoption Phase

2011 Study Measure Category	Related Bass Diffusion Segment Definition	Relationship to Codes and Standards Development	Possible TRC Range
Secondary measures	Laggards	Imminent code (i.e., next code cycle)	1.00
High Impact measures	Late Majority	Near term pending code	0.80 to 1.00
Measures of Interest	Early Majority	Being assessed for code adoption within (e.g., <5 years)	0.70 to 0.80
Measures of Interest and Emerging Technologies	Early Adopters	Possible code adoption Long term (e.g., >5 years)	0.50 to 0.70
Emerging Technologies	Innovators	No current code adoption view	0 to 0.50

1.3.2 Recommendations on Future Research on Select Potential Study Topics

This report was primarily an update to the 2008 potential study, with some additional focus on emerging technologies. As such, it was limited to reviewing and updating select activities but was not able to comprehensively update all existing potential estimates, or address all new sources of potential. For example:

- **Impact of financing on market potential:** This study did not include a review of how financing initiatives might influence market potential. Historically, market potential is based on various incentive levels that are designed to offset some percentage of incremental measure costs, thereby compelling consumers to adopt energy efficiency measures. As adoption rates increase, the difference between economic and market potential narrows. It is recommended that revisions to this study or future potential studies include a methodology to assess how financing influences customer actions and the resulting impact on market potential.
- **Updated market surveys for industrial sectors:** This report provides an update to the estimates of technical, economic, and market potential for the industrial sector by updating some of the parameters used in the 2008 potential study. However the 2011 update did not include a detailed review of measure assumptions because of resource constraints and lack of primary data about various aspects of the industrial market, such as measure saturation.

  The availability of current data was not as significant an issue in the commercial and residential sectors because of the 2006 commercial end-use survey,[25] 2010 residential appliance saturation survey,[26] and significant data available on high-impact measures available through the 2006–2008 EM&V project. In contrast, the industrial market is a complex blend of 122 measures

[25] California Energy Commission (CEC), California Commercial End-Use Survey, CEC-400-2006-005, Prepared by Itron, Inc., March 2006, Final report available at: http://www.energy.ca.gov/ceus/index.html. Data available at: http://capabilities.itron.com/ceusweb/.

[26] California Energy Commission (CEC), California Residential Appliance Saturation Study: CEC-200-2010, Prepared by KEMA-Xenergy, October 2010.

installed across various industries as defined by 20 North American Industry Classification System (NAICS) codes. After eliminating redundant applications, this blend of measures and NAICS codes yields a matrix of approximately 1,050 measure applications, many of which are unique within each NAICS market definition. Each measure application has its own set of metrics necessary to inform a potential study, such as useful life, measure savings, and saturation. The 2008 potential study indicated that it is primarily an update to the 2006 potential study. Navigant reviewed the data sources that the 2006 study used to inform its results and found that the study vintages ran from 2004 to 1999, as shown in Table 5. Based on this lineage of updates and sources, the results for the industrial sector in this study are very preliminary and require further work.

Table 5. Study Vintages Used to Inform the 2006 Industrial Sector Potential Estimates

Study Vintage	Number of Studies
2004	4
2003	6
2002	5
2001	8
2000	6
1999	4
1998	3
1997	8
1996	3
1995	1
1994	2
1985	1
Grand Total	51

» **Market survey for agricultural sector**: The estimate of potential developed for the agricultural market lacks the significant field research necessary to develop a robust estimate, similar to the industrial sector. In addition, a detailed potential study of the mining sector has never been undertaken. It is likely that the industrial, mining, or agricultural sectors, which account for 25% of statewide combined IOU electric energy consumption, are fully understood, including the potential for emerging technologies. It is therefore recommended that resources be made available to complete a full potential study on the industrial, agricultural, and mining sectors that include field research on consumers in those markets.

2 Introduction

This section provides a brief introduction to the contents of this report, including a background discussion and summary of the study goals. This section also provides a summary of the report organization to facilitate reader navigation of its contents.

2.1 *Overview of Study Objectives and Scope*

The primary objective of the Potential, Goals and Targets Study (PGT) is to provide a comprehensive quantitative assessment of energy savings potential in order to help the CPUC frame and choose energy efficiency goals in a way that best meets the CPUC's policy objectives. Within the PGT study, this report is referred to as the 'Track 1' study and represents an update to the 2008 potential study. Track two of the PGT study will be focused on establishing goals and targets for the California IOU portfolio of energy efficiency programs for the period beginning in 2015, and is expected to be completed in late 2012.

The 2008 potential study presented a comprehensive and detailed assessment of energy efficiency potential for the four California Investor-Owned Utilities[27] (IOUs) under 10 scenarios. The 2011 potential study presents results based on inputs from one of the 10 scenarios presented in the 2008 potential study, mid case scenario[28] as defined in the Preliminary California Energy Demand Forecast 2012-2022 (CED 2011 Preliminary)[29]. The mid case was selected because it presented a reasonable basis for projecting energy efficiency potential over the timeframe of the 2011 potential study.

Navigant's approach to the potential study builds upon the standard bottom-up[30] methodology that has been used in many states and is consistent with the CPUC's past goal-setting approach. Total energy use is calculated in a bottom-up fashion as the product of end-use energy intensities (e.g. kWh[31]/household or kWh/ft2), end-use equipment saturations, and the number of households (residential) or floor area (commercial) by building type.

Using updated assumptions ensured that the 2011 potential study benefited from the latest estimates of baseline end-use equipment ownership and load profiles, along with the latest estimates of energy efficiency measure costs, savings, and saturation levels across the service territories of California's four IOUs. Consistent with the previous study, the 2011 potential study has three analytic components:

1. <u>Technical Potential Analysis</u>: Technical potential is defined as the amount of energy savings that would be possible if all technically applicable and feasible opportunities to improve energy

[27] Pacific Gas & Electric, Southern California Edison, Southern California Gas, and San Diego Gas & Electric

[28] The CED 2011 Preliminary forecast includes three demand scenarios: high, mid, and low. The high demand case incorporates relatively high economic/demographic growth, low electricity and natural gas rates, and low efficiency program and self-generation impacts. The low demand case includes lower economic/demographic growth, higher assumed rates, and higher efficiency program and self-generation impacts. The mid-case uses input assumptions at levels between the high and low cases.

[29] Kavalec, Chris, Tom Gorin, Mark Ciminelli, Nicholas Fugate, Asish Gautum, and Glen Sharp, Preliminary California Energy Demand Forecast, 2012-2022, 2011, CEC-200-2011-011SD, available at: http://www.energy.ca.gov/2011publications/CEC-200-2011-011/CEC-200-2011-011-SD.pdf.

[30] A 'bottoms up' study is based on estimating the individual potential for each of a range of measures and then combining these individual measure level estimates to form an aggregate, service territory wide estimate.

[31] kilowatt hour, or kilowatt-hour, (kWh) is a unit of energy equal to 1000 watt hours

efficiency were taken, including retrofit measures, replace-on-burnout[32] (ROB) measures, and new construction measures. This view includes the potential from emerging technologies that may enter the market at some point during the time frame of the analysis, and the impact that codes and standards have on changing the baseline that defines what is considered additional energy efficiency savings and what is considered standard practice.

2. Economic Potential Analysis: Using the results of the technical potential analysis, the economic potential is calculated as the total EE potential available when limited to only cost-effective measures. Consistent with the 2008 potential study's mid-case scenario, the economic potential in this report is limited to measures that achieve a Total Resource Cost test[33] (TRC) ratio of 0.85 or better, with an incentive equal to 50% of incremental cost.

3. Market Potential Analysis: The final output of the potential study is a market potential analysis, defined by the amount of customer measure adoption, and resulting savings, that could be expected to occur in response to specific levels of program funding and measure incentives over time and assumptions about market influences and barriers. Market potential is expressed as cumulative and annual incremental potential. Annual incremental potential is considered to be the best estimate of ex post gross potential that a portfolio of programs could achieve for a given year.

For the final 2011 potential study, Navigant converted the EERAM model from an excel file into a new Potential, Goals and Targets Model discussed in detail in Section 3, modeling was completed employing the following three steps:

1. Obtain key inputs from the 2008 model, including the following parameters. A detailed description of the model inputs and data sources for the EERAM modal can be found in Appendix C and the measure input characterization (MICS) files[34] that accompany this report.

    » Base and energy-efficient technology densities for each technology considered;

    » Energy (KWh and therms) and demand impacts (kW)

    » Efficiency measure costs (typically dollars per measure or measure specific common unit such as dollars per square foot)

    » Efficiency measure life in years

    » Decision-maker estimates of measure awareness and willingness to purchase based on California evaluation data or Navigant industry data

    » Technology applicability

    » Building stock totals

---

[32] Equipment that has failed while in operation and needs to be replaced

[33] The Total Resource Cost Test ('TRC') is applicable to conservation, load management, and fuel substitution programs. It is the ratio of net program benefits to net program costs. The net benefits calculated in the TRC are the avoided supply costs, the reduction in transmission, distribution, generation, and capacity costs valued at marginal cost for the periods when there is a load reduction. The net costs of a demand-side management program as a resource option based on the total costs of the program, including both the participants' and the utility's costs. California Standard Pract5ice Manual Economic Analysis of Demand Side Management Program and Projects, October 2001

[34] The MICS are a repository of all measure-related inputs for EERAM, for public review purposes. A separate MICS was developed for each unique combination of sector and utility. A complete list of MICS along with the utility, sector, and fuel type are publicly available on CPUC's Energy Data Website.

2. Update inputs based on the most current data. This step included an assessment of the underlying savings assumptions for energy efficiency measures. These updated values, and associated reference sources, can be found in the Measure Inputs Characterization sheets (MICs) that accompany this report.
3. Produce the model and calibrate to the 2006-2008 evaluation study results, review the model outputs in a series of engagements with stakeholders, and refine the forecast estimates as discrepancies and inconsistencies are identified.

2.1.1 Changes in the Analysis since the November 2011 Draft Report[35]

In November 2011 the Navigant team released a draft of this report, including the associated models used in the analysis. By the close of the review period, over 20 parties had submitted comments on the report and associated modeling effort. The Navigant team, in conjunction with the Energy Division, reviewed these comments and made revisions to the model that changed the estimates of savings potential presented in the draft report. As Table 6 shows, the 2013–2014 incremental market potential (gigawatt-hours [GWh]) in the aggregated IOU savings estimates remain largely unchanged since the November report, while estimates of potential in the further out years increase. Table 6 also shows that the distribution of savings among sectors changed, sometimes significantly. These changes are due to revisions that resulted from stakeholder feedback and additional modeling effort, including the following:

» Changes to the approach used to calibrating the model to include ex post gross accomplishments for the 2006 program year. The previous model excluded 2006 and began the calibration period in 2007. Additionally, the approach used to calibrate the model in June 2011 was revised to calibrate the model more accurately for market potential.

» Increase in estimates of potential for the low-income (LI) market subsector based on a further review of the 2007 Low-Income Needs Assessment (LINA)[36] study.

» Changes in estimates of participation rate in residential behavioral programs, including revised estimates in the level of overall savings from these initiatives, and also in the percent of savings derived from changes in usage-based behavior versus changes in equipment-based purchasing behavior.

» Added an estimate of technical, economic, and market potential from the agricultural sector. This is the first estimate of potential completed by the Energy Division for this sector and the study was completed with the support of the 2010-2012 Statewide Agricultural Market Characterization & Energy Efficiency Potential Study.

» Corrected modeling errors in the estimates of potential in the industrial sector.

» Added several new emerging technologies to both the commercial and residential market sectors.

» Revised the approach used to estimate savings resulting from refrigerator recycling initiatives.

[35] Analysis to Update Energy Efficiency Potential, Goals, and Targets for 2013 and Beyond, Track 1 Statewide Investor Owned Utility Energy Efficiency Potential Study Draft. Prepared for the California Public Utilities Commission, Navigant Consulting, Inc., November 7, 2011.

[36] KEMA, Phase 2 Low Income Needs Assessment, California Public Utilities Commission Final Report, September 7, 2007.

- Updated the expected useful life (EUL) for linear fluorescents to match DEER values. This changed the EUL on linear fluorescent measures from an average of approximately 5 years to an average of approximately of 15 years..
- Revised the per unit energy savings from set top boxes and EMS (gas) based on secondary research.
- Revised the modeling methodology for Retro-commissioning (gas) and Steam Traps (gas) to better represent actual program actions. Retro-commissioning measures have a refreshing population, as more buildings are available for retro-commissioning over time. Although updates have been made, more research is needed on Retro-commissioning as it is expected to be a major part of utilities gas portfolio in the future. Additional investigation will allow this relatively custom measure to be accurately profiled. For example, the EUL of retro-commissioning measures is not well understood (DEER recommends a EUL of 10 years which may be too long).
- Removed any savings potential associated with retrofits involving replacing T12 lamps with T8 lamps after the year 2013.

Table 6 presents changes in electric potential energy savings estimates from the November draft report.

Table 6. Changes in Reported Estimates of Market Potential, by Sector (GWh)

Version	Sector	2013	2014	2015	2016	2017	2018	2019	..	2024
Current Report	Residential	375	372	412	438	449	400	399	..	366
	Commercial	645	646	657	657	664	735	743	..	783
	Industrial	289	275	260	249	233	224	208	..	176
	Agricultural	89	87	85	86	82	80	78	..	81
	Statewide	1,397	1,379	1,414	1,429	1,430	1,439	1,428	..	1406
November Draft Report	Residential	710	624	570	532	490	406	396	..	334
	Commercial	615	581	541	561	563	533	523	..	268
	Industrial	205	211	215	218	218	218	219	..	252
	Agricultural	0	0	0	0	0	0	0	..	0
	Statewide	1,530	1,417	1,327	1,311	1,271	1,157	1,138	..	854
Change	Residential	-47%	-40%	-28%	-18%	-8%	-1%	1%	..	10%
	Commercial	5%	11%	21%	17%	18%	38%	42%	..	192%
	Industrial	41%	30%	21%	14%	7%	3%	-5%	..	-30%
	Agricultural	100%	100%	100%	100%	100%	100%	100%	..	100%
	Statewide	-9%	-3%	7%	9%	12%	24%	25%	..	65%

2.2 *California Energy Usage and Efficiency Program Background*

2.2.1 Electricity Usage and Energy Efficiency Portfolio Background

Figure 9 provides historic and projected energy use forecasts for five key market sectors estimated by the CEC as part of the 2011 IEPR development process.[37] These sectors account for approximately 94% of forecast consumption in 2013. Table 7 shows residential and commercial forecasted consumptions

[37] Source: California Energy Commission

increasing at between 2.03% and 1.50%, respectively, between 2010 and 2022, while manufacturing, mining, and agricultural forecasts indicate slight decreases in consumption.

Figure 9. Historic and Projected Energy Consumption by Sector (GWh)

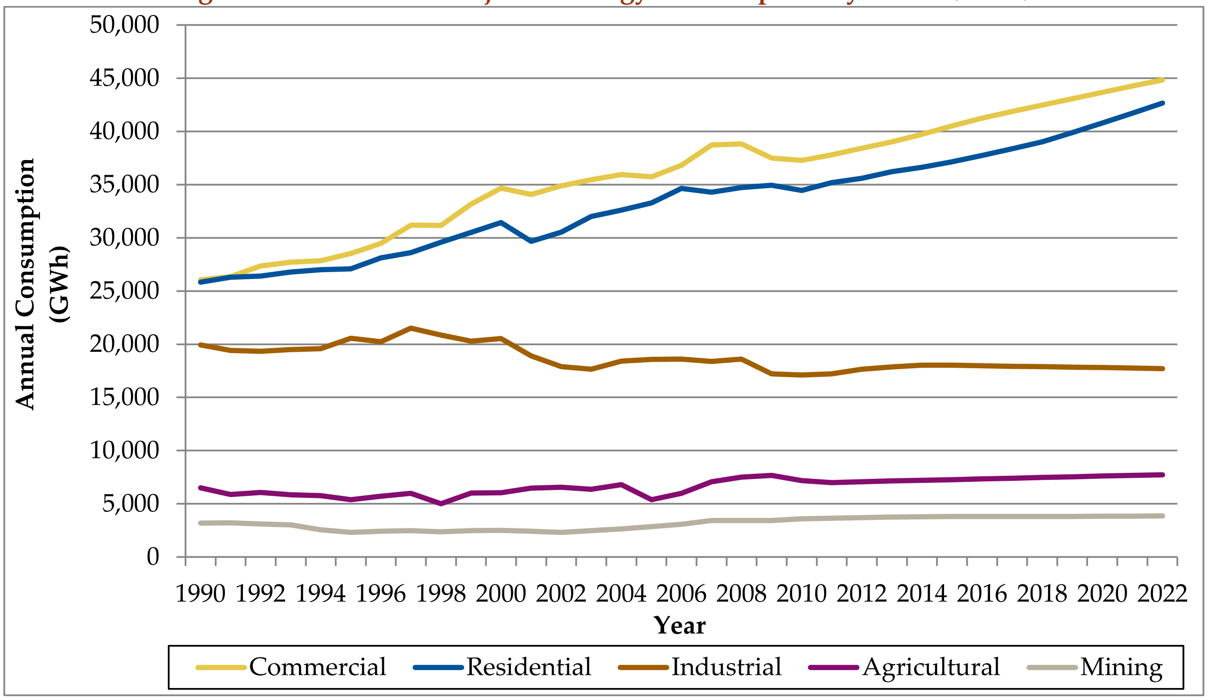


Table 7. Mid-Case Annual Growth Rates Forecasts (%)

Year	Residential	Commercial	Manufacturing	Mining	Agricultural	Total Consumption
1990-2000	1.68%	2.82%	0.57%	-1.32%	-0.24%	1.59%
2000-2010	0.92%	0.85%	-2.32%	1.38%	0.33%	0.18%
2010-2015	1.88%	1.64%	0.57%	1.11%	-1.10%	1.36%
2010-2022	2.03%	1.50%	-0.03%	0.45%	-0.40%	1.27%

As noted previously, the 2011 potential model is calibrated to ex post gross and net savings from the 2006–2008 portfolio evaluation project. Based on an analysis of the Energy Division report summarizing the results of that evaluation,[38] Table 8 shows that the commercial sector provided the greatest source of net savings, while Table 9 indicates that 81% of savings originated from three broad measure categories. Table 8 shows the commercial sector contributed 75% of therm savings[39] and Table 10 shows that 94% of all therms savings for the commercial, industrial, and agricultural sectors came from the heating, ventilating, and air-conditioning (HVAC) and process measure categories. While these values provide context for historic performance, changes in codes and standards occurring over the next several years will likely modify the measures and sector weights.

[38] DRAFT 2006-2008 Energy Efficiency Evaluation Report, California Public Utilities Commission, April 15, 2010.
[39] The residential sector did not report therm savings for the 2006-2008 portfolio.

Table 8. 2006–2008 Portfolio Evaluated Annual Net Electric and Gas Energy Savings and Demand by Market Sector

Market Segment	GWh	MW	Therms
Commercial	46%	52%	75%
Residential	38%	35%	NA
Industrial	11%	8%	12%
Agricultural	4%	5%	13%
Total	100%	100%	100%

Table 9. 2006–2008 Portfolio Annual Net Electric Energy Savings by Measure Group for All Sectors

Measure Category	Energy (GWh)	Demand (MW)
Indoor Lighting	59%	51%
Process	12%	10%
HVAC	10%	23%
Appliance	6%	5%
Refrigeration	5%	3%
Outdoor Lighting	3%	1%
Whole building	3%	3%
Plug Loads	1%	0%
Survey	1%	1%
Water Heating	0%	1%
Building Envelope	0%	1%
Laundry	0%	0%
Food Service	0%	0%
Other	0%	0%
Greenhouse	0%	0%
Total	4,064	770

Table 10. 2006–2008 Portfolio Annual Net Therm Energy Savings by Measure Group for All Sectors

Measure Category	Percent of Ex Post Net Therm Savings
HVAC	49%
Process	45%
Water Heating	5%
Greenhouse	3%
Food Service	2%
Whole Building	1%
Indoor Lighting	-5%
Grand Total	100%

2.2.2 Background on California Energy Efficiency Goals

Since the 2008 potential study was conducted, there have been a number of state initiatives and Commission decisions that have impacted energy efficiency goals. All of these policies will be modeled in Track 2 of the PGT Study. However, some of these initiatives will be modeled in the potential study and others do not have a direct role in determining market potential, as indicated below.

The following are state and federal legislative requirements included in the potential study:

- **Assembly Bill 1109:** Adopted in 2007, the Huffman Bill requires the state to set standards for general service lamps so as to achieve specific reductions in "average" residential and commercial lighting consumption by 2018. The regulations, in combination with other programs and activities affecting lighting use in the state, would be structured to reduce statewide electrical energy consumption by not less than 50% from the 2007 levels for indoor residential lighting and not less than 25% from the 2007 levels for indoor commercial and outdoor lighting by 2018.
- **Title 24 Update:** The Energy Efficiency Standards for Residential and Nonresidential Buildings were established in 1978 in response to a legislative mandate to reduce California's energy consumption. The standards most recently were updated January 1, 2010, and supersede the 2005 Standards to incorporate new energy efficiency technologies and methods.
- **Federal Appliance and Equipment Standards:** The U.S. Department of Energy (DOE) is updating a number of the appliance and equipment standards in 2011, which will take effect in 2012.

The following are state legislative requirements that are assessed in the Goals Study:

- **AB 758:** AB 758 (Skinner, 2009) requires the CEC to develop and implement a comprehensive program to achieve greater energy savings in the state of California's existing residential and nonresidential building stock. The CEC will conduct regulatory proceedings to establish an energy efficiency program directed at existing buildings that fall significantly below the efficiency required by the current Title 24 Standards. The outcome of the proceeding is yet to be determined, and will not provide information that might increase the economic or market potential, but will be further assessed in the Goals Study, based on outcomes that emerge from the CEC's planning efforts.

» **AB 1103:** Adopted in 2007, the Commercial Building Benchmarking bill mandates energy benchmarking and energy disclosure for non-residential buildings. It requires non-residential business owners to input energy consumption and other building data into the U.S. Environmental Protection Agency's (EPA's) ENERGY STAR Portfolio Manager System, which generates an energy efficiency rating for the building. There has been no quantifiable energy savings data associated with this legislation to date.

The following CPUC Decisions will be incorporated in the potential study:

» **Cost-Effectiveness Update:** The energy efficiency cost-effectiveness methodology was adopted in D.05-09-043 and updated in D.06-06-063, and modeled by Energy + Environmental Economics (E3) to inform the 2004 and 2008 goals. The Assigned Commissioner issued a ruling in R. 09-11-014 on December 23, 2010, that enumerated the list of cost-effectiveness parameters to be updated and incorporated into this study.

» **Total Market Gross:** In the decision adopting the 2008 Goals update , the CPUC determined that in future cycles it should adopt goals on a "Total Market Gross" (TMG) basis. This was a policy shift in two respects. First, "total market" refers to policy initiatives beyond those historically pursued through utility programs. For example, the goals adopted in D.08-07-047 explicitly include codes and standards, which the utilities do not have the authority to implement themselves, although they have pursued programs intended to increase compliance. Second, "gross" means that ancillary consequences of programs, such as free ridership and spillover, would be counted toward the goal. This policy shift therefore means that a variety of savings sources now count toward goal achievement. For future portfolio cycles, the Energy Division distinguishes "goals" on a total market gross basis from IOU specific "targets"—the portion of expected energy efficiency that the IOUs are expected to achieve through their program portfolio. The TMG goals are used in the IEPR forecast for long-term procurement planning and as the greenhouse gas (GHG) reduction benchmark, while the targets are used for IOU portfolio planning and may be considered in setting the benchmark for the Risk Reward Incentive Mechanism (RRIM).

» **Strategic Plan:** The Air Resources Board (ARB) Climate Change Scoping Plan for AB 32 indicated that the state must intensify its energy efficiency efforts in order to meet its GHG reduction targets, setting a preliminary target of at least 32,000 GWh and 800 million therms by 2020. To meet this target, the CPUC worked with multiple stakeholders and state agencies to develop the Long-Term Energy Efficiency Strategic Plan (2008), which would identify new collaborative initiatives across market sectors and cross-cutting areas. The Strategic Plan was also intended to accelerate the improvement of cost-effective EE technologies and program delivery mechanisms over time. The plan identifies a number of strategies that move beyond utilities' traditional programs, lays the groundwork for implementation, and includes numeric goals associated with the list of strategies. As some of these strategies are untested and rely on a number of public and private partners to implement, the Energy Division does not necessarily foresee including these goals directly in the TMG goals or the EE targets that the RRIM will be based on.

2.3 *Organization of Report*

- Sections 1 and 2, Executive Summary and Introduction, provide an overview of the context for the report and key findings and recommendations.
- Section 3, Model Overview, provides a brief technical description of the EERAM model structure and Analytica platform used to develop the model. Section 4, Modeling of Key Energy

Efficiency Sources, provides an extensive discussion on the approach used to develop key inputs to various elements of the model.

- Section 5, California Energy Efficiency Potential, presets the energy and demand savings potential for the combined service territory of the four California IOUs, by sector. Sections 6, 7, 8, and 9 provide details on energy and demand savings potential for the residential, commercial, industrial, and agricultural sectors, respectively. Sections 10, 11, 12, and 13 discuss energy and demand potential for the four California IOUs
- Section 14 presents a summary of the findings and recommendations, and a discussion on select near term activities.

3 Model Overview

3.1 *Modeling Approach*

This potential study used Navigant's Energy Efficiency Resource Assessment Model (EERAM) to quantify technical, economic, and market potential for energy efficiency in the service territory of California's four investor owned utilities[40] ('IOUs'). The model forecasts energy savings and demand reduction potential within the residential, commercial, agricultural, and industrial sectors. The time period of the forecast is a model input variable that extends to 2024 with this implementation of EERAM.

EERAM was built in the Analytica platform. The model charts the interaction between the impacts and costs of energy efficiency for each measure, as well as utility customer characteristics, utility load forecasts, utility avoided costs, and rate schedules. Using a bottom-up approach, the model builds on the essential blocks of market saturation estimates, forecasts of new construction, energy efficiency technology data, past program performance, and market-based decision-making variables. Analytica allows multiple utility and sector results to be calculated and reported in the same model file.

3.2 *Model Methodology*

The model partitions its evaluation of each measure into technical, economic, and market potential. Each assessment includes building stock estimates (sales in the industrial sector), technology densities, and measure impacts. Each assessment of potential uses a different algorithm.

Technical potential is calculated using the product of a measure's savings per unit, the quantity of applicable units in each facility (in the case of industrial, the number of units per kWh of sales), and the number of facilities in a utility service's area. The assessment includes measures that might not be cost-effective or have the backing of a strong consumer market. By disregarding these factors, the technical potential assessment provides an upper bound of efficiency potential regardless of cost or market penetration. For measures considered to be replace on burnout, the quantity of applicable units per year is limited to the number that need to be replaced, which is determined by measure life. As time passes, this potential population grows until meeting the full measure life. For non-ROB measures, the full populations of baseline units are considered available. No net-to-gross (NTG) adjustments occur with technical potential.

Economic potential estimates the amount of technical potential that is "cost-effective," as defined by the results of the TRC test. The TRC test is a cost-benefit analysis of relevant energy efficiency measures, excluding market barriers such as lack of consumer knowledge. Benefits include avoided costs of generation, transmission and distribution investments, as well as avoided fuel costs due to energy conserved by energy efficiency programs. Costs include incremental measure costs and program administration costs. Replace on burnout measures are treated the same as technical potential and there are no NTG adjustments. For economic potential, the TRC is calculated for each measure using E3's avoided cost model and any measure with a TRC below .8 is screened out.

Market potential is the third of EERAM's energy efficiency algorithms, calculating the amount of economic energy efficiency potential that could be captured by utility energy efficiency programs over the forecast period. This calculation varies with the program's parameters, such as the magnitude of

[40] Pacifica Gas and Electric, San Diego Gas and Electric, Southern California Gas Company, and Southern California Edison

incentive or rebates for customer installations and program design. EERAM recognizes four types of program design, including:

- Replacement on Burnout: An energy efficiency measure is implemented after the existing equipment fails.
- Early Retirement (Early): An energy efficiency measure normally regarded as ROB is installed before its effective measure life is reached.
- Retrofit (RET): An energy efficiency measure that can be implemented immediately. The lifetime of the base technology is not a factor as RET measures generally do not replace existing technologies but rather improve the efficiency of existing technologies. The energy impact is therefore the amount of that improvement.
- New Construction (New): A measure or package of measures is/are installed at the time of new construction.

EERAM also calculates several financial tests, including:

- Total Resource Cost: Mentioned earlier, this test includes all quantifiable costs and benefits of an energy efficiency measure, regardless of who accrues them.
- Simple Customer Payback: This measurement calculates the program payback by taking the measure cost less the incentive received and divides it by first year energy bill savings.

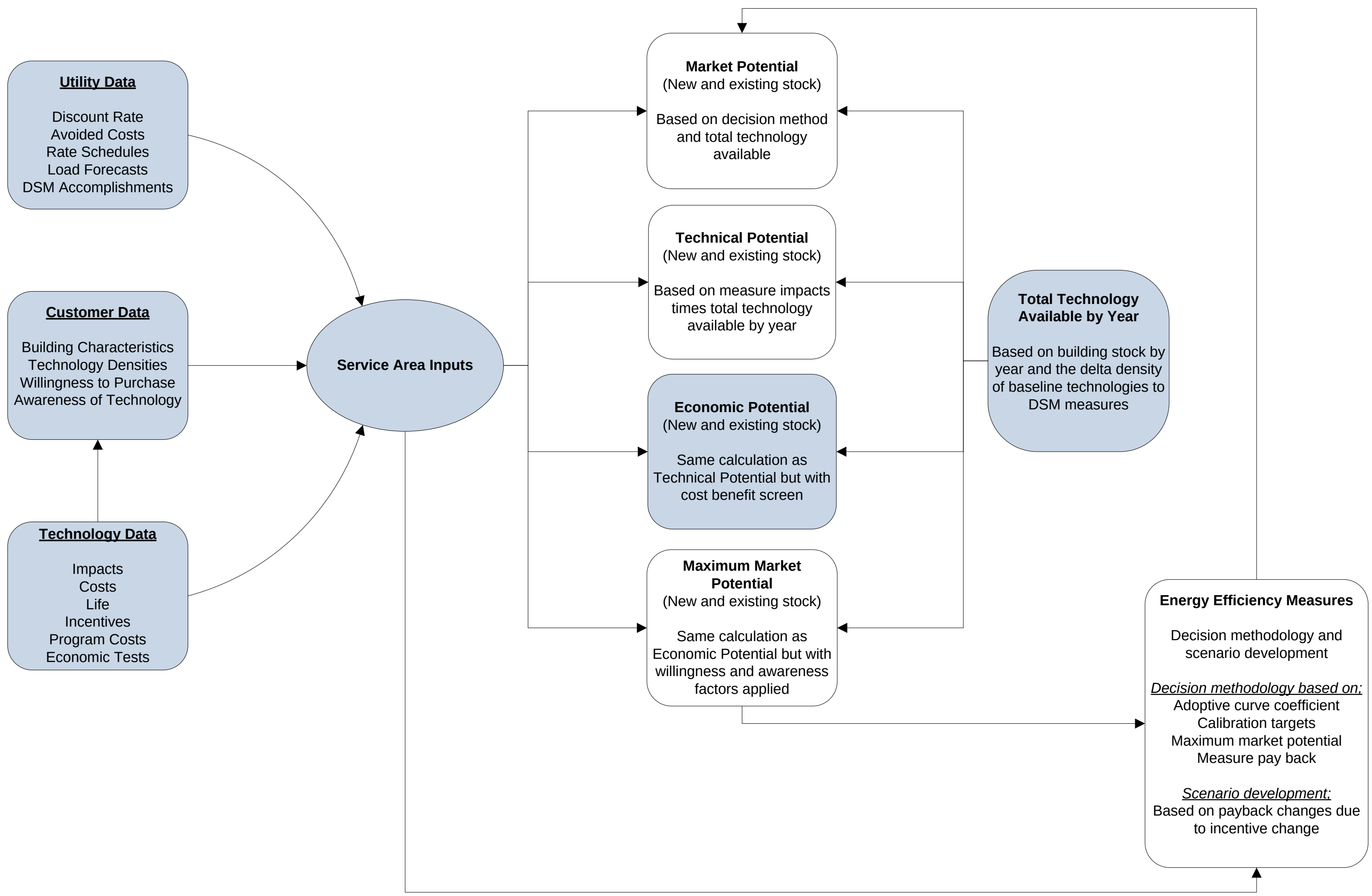
3.3 Model Flow Diagram

Figure 10 provides an outline of the various inputs to the EERAM model and connections to the calculation portions of the model. Outputs from the model are designed to accomplish multiple objectives, including the following:

- Determine the total cost-effective energy savings available over the forecast period on an annual and cumulative basis for 100% of retail energy use in IOU territories. These estimates are provided at the sector, program type, and end-use classification levels.
- Provide guidance for utilities' next energy efficiency portfolios at an aggregate level and at the measure category level, where appropriate.[41] To ensure continuity with previous estimates of potential, our analysis begins in 2007[42], the same year as the 2008 potential study, to allow for the direct comparison of results. In addition, the market potential output is calibrated to actual utility program achievements in 2007, 2008, and 2009.
- Present a platform to accommodate the need for an expanded view of energy efficiency potential based on the requirements of the loading order established in the Energy Action Plan and the needs of both the California Energy Commission's IEPR and the CPUC's Long Term Procurement Planning (LTPP) proceeding, and to inform analysis of California's greenhouse gas reduction targets.

[41] EERAM as used in this project is not meant to be used as a measure-by-measure program design tool.
[42] The model was calibrated in a way that included 2006 ex-post reported accomplishments, however the timeline for the calibration process begins in 2007.

Figure 10. EERAM Input Information and Model Calculation Flow

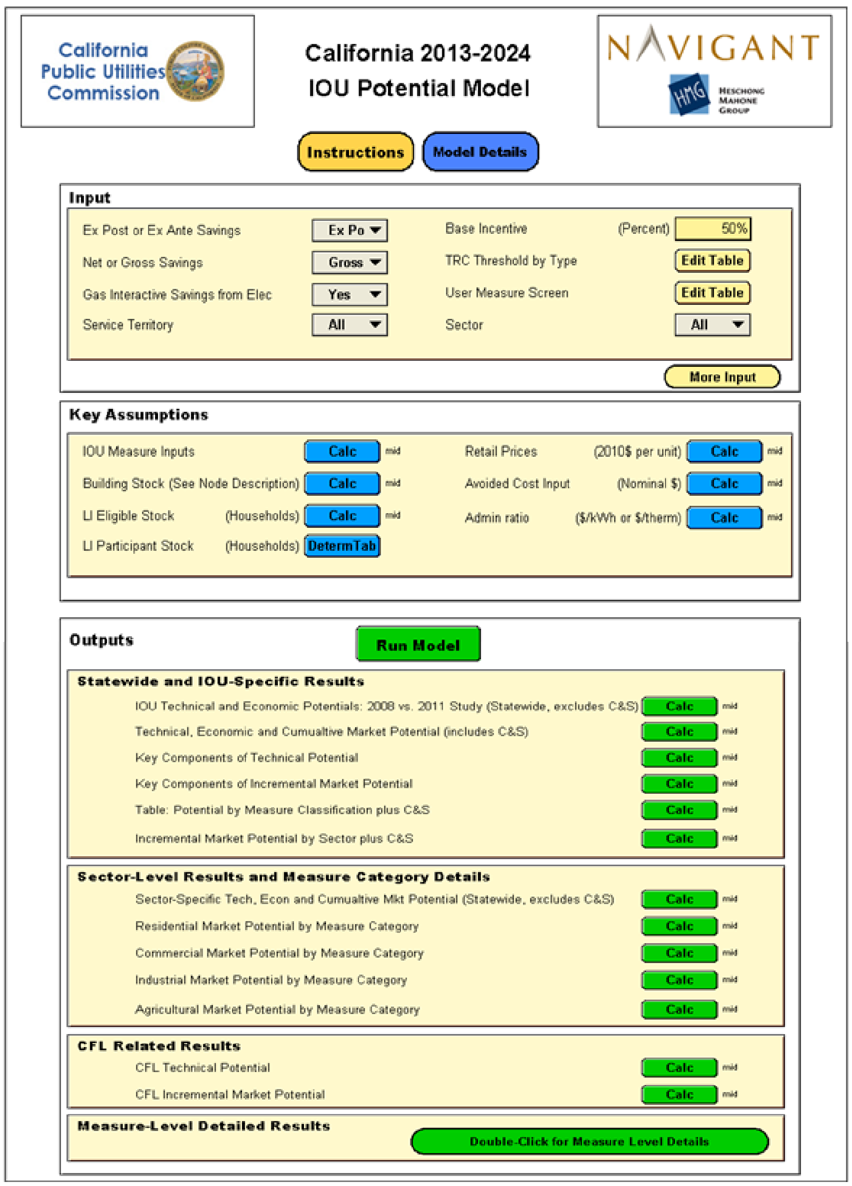


3.4 *Overview of Model*

EERAM is accessed through a user interface, illustrated in Figure 11. The model is segmented into four sections.

- Inputs – User editable inputs
- Key Assumptions – Fixed inputs that cannot be changed, but can be viewed
- Model Details – Model calculations
- Outputs – Output graphs and tables

Figure 11. EERAM User Interface



3.4.1 Inputs

The top section of the EERAM user interface provides the list of scenario assumption inputs that can be used to adjust the results of the EERAM model, as well as the rolled-up outputs. It contains primary variables that help define scenarios and identify utility service area variables. The primary user editable inputs are:

» An either/or selection switch for use of ex ante or ex post measure impacts

» An either/or selection switch for use of a net-to-gross adjustment factor

» On/off switch to include Interactive Effects on heating and cooling end uses

» Base incentive level (expressed as a percentage of incremental measure cost)

» TRC screening threshold value by measure type[43] (high impact measures (HIM) , emerging technologies (ET), measures of interest (MOI), low income (LI), Behavior, and Secondary measures)

» TRC screening override

» Choice to run all utilities or just a single utility

» Choice to run all sectors or just a single sector

Two additional inputs can be adjusted if desired. These are the IEPR defined values from the CEC's mid, high, and low forecasts for:

» Retail price case

» Building stock case

3.4.2 Key Assumptions

The second section of EERAM allows users to view key assumptions made by the study team. The key assumptions section does not contain the full list of assumptions; but rather those assumptions that are most crucial to calculating energy efficiency potential. These key assumptions include:

» IOU measure inputs

» Building stock forecast

» Retail energy prices

» Avoided costs

» Low-income building population

3.4.3 Outputs

The user interface contains an extensive set of output graphs. The graphs that appear in the model replicate the data that is used for the figures in this report. The outputs provide some additional views of data beyond what is contained in this report. Key outputs include:

» Technical, Economic, and Cumulative market potential for each IOU service territory and sector, as well as a statewide roll-up

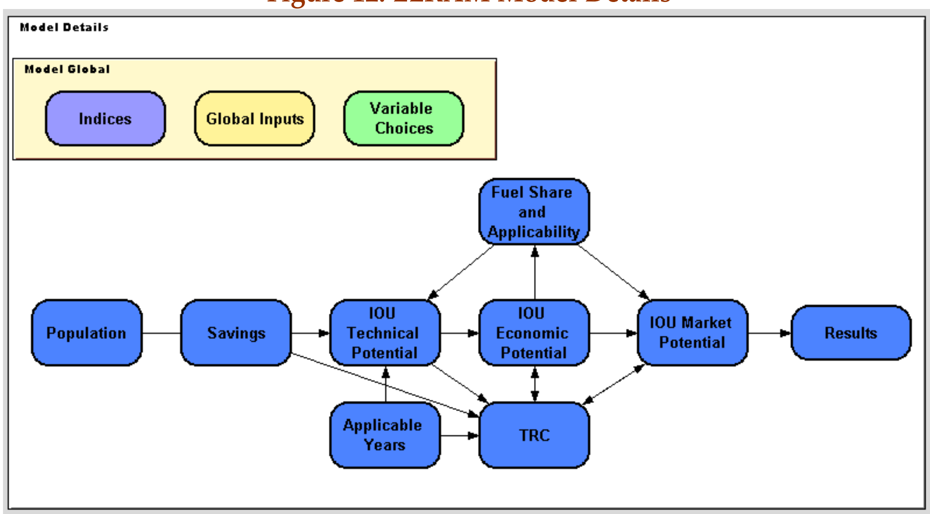
[43] Further defined in Section 4 and Appendix M: EERAM Model Algorithm and Input Details

» Incremental market potential broken down by sector with the addition of codes and standards savings for each IOU, as well as a statewide roll-up
» Sector-specific incremental market potential by measure category (e.g., HVAC, Lighting)
» Tables of all potential types for all measures in each service territory

3.5 Model Details

The model details contain all the calculations and the full extent of inputs assumptions made by the study team. The model details can be accessed by clicking on the blue icon labeled "Model Details" at the top of the user interface. The model details section is illustrated in Figure 12.

Figure 12. EERAM Model Details



A short description of each of the modules follows, with more detailed considerations for select modules following the list:

» **Indices:** A list of the indexes over which the model operates. Example indexes include simulation years (2007-2024), IOUs (Pacific Gas and Electric [PG&E], Southern California Edison [SCE], Southern California Gas [SCG], San Diego Gas and Electric [SDG&E]), measure savings type, and more.

» **Global Inputs:** Contains the major global inputs such as measure data, building stocks, retail prices, avoided costs, discount rates, and more

» **Variable Choices:** Contains functions that enable user input

» **Population:** Calculates the total applicable population of units for each measure in each simulation year

» **Savings:** Extracts ex post and ex ante savings data for each measure. Makes several adjustments for code-based changes and non-code changes (due to technology improvements over time)

» **Fuel Share and Applicability:** Mainly determines those measures that are expected to compete against each other for technical potential savings

- **Applicable Years:** Calculations regarding when a measure is expected to be available to the mass market
- **IOU Technical Potential:** Contains calculation methodology for technical potential
- **TRC:** Calculates measure-level TRC to be used for screening measures in the economic potential. Accounts for technology costs, changes in technology costs, administrative costs, and user-defined TRC thresholds
- **IOU Economic Potential:** Contains calculation methodology for economic potential
- **IOU Market Potential:** Contains calculation methodology for incremental and cumulative market potential including calibration, diffusion, and reparticipation algorithms.
    - **Calibration:** The calibration node is a part of the IOU Market Potential node. In this node, the model is calibrated to actual evaluated energy savings data from 2007 through 2009.Calibration ensures that the energy savings potential calculated by the model reflects the actual achievable savings potential of the modeled region. Further details of the calibration methodology are presented in Appendix M.
- **Results:** Summarizing calculations that generate the output datasets which are graphed on the user interface

The following provides a brief discussion on several of the key modules shown in Figure 12.

3.5.1.1 Savings Module

The savings module makes several adjustments for code-based changes and non-code changes:

- **Non Codes and Standards:** First-year measure impact estimates as well as three baseline estimates of measure impacts come from the IOU Measure Inputs table. The first baseline is for the years 2007 through 2009. These baseline impact estimates are intended to represent the DEER values at that time and are the basis for the values used in the 2008 potential study. The second, for the years 2010 through 2012, is intended to represent the DEER values at that time, which were the basis for the utility filings during this time frame. The third baseline is for the year beginning in 2013 and is designed to represent the best available estimates of measure impact. If impacts are expected to change over time (non-code changes), they are identified by measure here. The changes happen after 2013.
- **Codes and Standards:** Codes and standards significantly affect measure impacts for some measures over time. Estimates of changes to measure impacts from codes and standards, at the measure level, are identified here.

3.5.1.2 IOU Technical Potential Module

Technical potential is calculated on a per measure basis, as the product of a measure's savings per unit, the quantity of applicable units in each facility (in the case of industrial, the number of units per kWh of sales), and the number of facilities in a utility service's area.

For measures considered to be replace on burnout, the quantity of applicable units per year is limited to the number that need to be replaced, which is determined by measure life. As time passes, this potential population grows until measure life is equaled. For other, non-ROB measures, the full populations of baseline units are considered available.

The technical potential is calculated each forecast year. It reflects not only consideration of populations because of ROB assumptions, as described above, and changes to measure impacts over time. Building stocks are treated differently for new construction. Here, the technical potential is a running cumulative total for each year of the forecast. No net-to-gross adjustments occur with technical potential.

3.5.1.3 Total Resource Cost (TRC) Module

Technology costs, administrative costs, and avoided costs are the main cost components of the TRC calculation. The model allows for technology cost to change over time. The time vector of any cost changes by measure is included in this module. Similarly, the model allows for administrative cost to change over time. The time vector of any administrative cost changes by measure is included in this module. The avoided costs are calculated for each measure and for each year in the forecast. The calculation takes the form:

> **PV Avoided Costs** = PV (Discount Rate, Technology Life, Annual Avoided Costs * Net to Gross)

The TRC values are calculated for each measure and for each year in the forecast. The TRC calculation takes the form:

> **Total Resource Cost Test** = Avoided costs / (Administrative costs and technology cost)

In addition to calculating TRC values for each year by measure, the model also identifies the competition share for those measures within competition groups. The share is calculated each forecast year and is based on each measures share of individual TRC to the competition group TRC sum.

3.5.1.4 IOU Economic Potential Module

Economic potential estimates the amount of technical energy efficiency potential that is "cost-effective," as defined by the results of the TRC test. The TRC test is a cost-benefit analysis of relevant energy efficiency measures, excluding market barriers such as lack of consumer knowledge. Benefits include avoided costs of generation, and transmission and distribution investments, as well as avoided fuel costs due to energy conserved by energy efficiency programs. Costs include incremental measure costs and a program's administration costs. The treatment of new construction, ROB measures, and net-to-gross is the same as with technical potential.

As with technical potential, economic potential is estimated by measure for each year of the forecast. The TRC screen used to identify economic potential, which is also re-calculated each year in the forecast, can have significant effects on economic potential and the economic potential curve may be a different shape compared to technical potential. Measures can fall in and out of economic potential based on the year-by-year screening.

The value of the TRC screen is a variable set on the user interface. The value most commonly used is 0.8. This is less than 1.0 at the measure level, but is designed to allow for a packaging of measures around the TRC of 1.0 that gives a program package TRC value of 1.0 or greater.

3.5.1.5 IOU Market Potential Module

The market potential module contains calculation methodology for incremental and cumulative market potential including calibration, diffusion, and reparticipation algorithms. Several of the key algorithms are described in Appendix M.

3.6 *Default Modeling Scenario Definitions*

The Model Interface for the EERAM model includes several switches and settings that affect model output. These switches and the default setting used in this study include:

- **Ex Post or Ex Ante Savings: (Default set to Ex Post):** An either/or selection switch for use of *ex ante* or *ex post* measure impacts
- **Net or Gross Savings - (Default set to "Gross"):** An either/or selection switch for use of a net-to-gross adjustment factor
- **Gas Interactive Savings from Elec. (Default set to "Yes"):** Yes/No switch to include Interactive Effects on heating and cooling end uses. Setting the switch to "No" allows the user to see the effects of the measures specifically designed for natural gas efficiency improvement.
- **Service Territory (Default set to "All"):** Allows the user to run the model in either one of four IOUs or for all IOUs simultaneously. Note: The model runs faster when selecting only one IOU.
- **Scenario Incentive - (Default set to 50%):** Incentive level, expressed as a percentage of incremental measure cost that can be varied by the user. Model results for incentives beyond 100% are not valid.
- **TRC Screen Threshold by Type - (Default set to 0.5 for Emerging Technologies, 0.8 for HIM, MOI and Secondary, 0.0 for Behavior and Low-Income):** TRC screening value by measure type. The user can set different TRC screening values based on whether the measures are High Impact, Secondary, Measures of Interest or Emerging Technologies.
- **User TRC Override:** This switch allows users to include select measures in market potential calculations disregarding their TRC (i.e., force to include measures that fall below the TRC screen threshold).
- **Sector - (Default set to "All"):** Allows the user to run the model in either one of four sectors (Residential, Commercial, Industrial, and Agricultural) or for all sectors simultaneously.

The user can modify other inputs apart from the ones displayed on the user interface. These can be accessed by double-clicking the "More Input" button. These are:

- **Building Stock Case - (Default set to "Medium"):** IEPR-defined values from the California Energy Commission's (medium, high, and low forecasts for Building stocks
- **Retail Price Case- (Default set to "Medium"):** IEPR-defined values from the CEC's medium, high, and low forecasts for Retail Prices

In summary, the EERAM model assumes the medium IEPR forecast with ex ante savings, a net-to-gross of 1.0, and no interactive effects. The TRC screen is 0.8; incentives are set to 50% of incremental technology cost with codes and standards, new construction, emerging technologies, and behavioral programs included.

4 Modeling of Key Energy Efficiency Sources

This section describes the methods and assumption for modeling the various sources of energy efficiency potential, specifically CFLs, refrigerator recycling, emerging technologies, behavioral initiatives, new construction, and codes and standards. Additional details on modeling assumptions can be found in Appendices B thru M.

4.1 Measure Data Source Priority

All measures modeled in EERAM are categorized by perceived importance of each measure to a utility's recent portfolios or potential for future contributes, based on historic savings potential or energy intensity of end use. While all categories were included in the study, the categories of measures received more intensive review of input assumptions depending on their level of importance. The categories were in the following rank order:

1. **HIMs (High Impact Measures):** Measures with highest savings contributions to a utilities portfolio are designated as HIMs. In the 2006 -08 evaluation cycles, a measure was classified as a HIM for a particular utility if it accounted for more than 1% of that utility's claimed savings. Altogether HIMs accounted for approximately 85 % of portfolio kWh, kW and therm savings in the 2006-08 evaluation cycle. These measures include residential and commercial CFLs, residential refrigerator recycling among other measures. While developing measure inputs, special attention was given to measures categorized as HIMs and resources were prioritized such that HIMs were given priority over other measure categories.
2. **Secondary Measures:** These are the measure that are expected to become high impact measures once the energy savings potential for the current crop of HIMs is exhausted. Custom measures were also included as secondary measures.
3. **MOI (Measures of Interest):** These are measures that are present in the utility portfolio; but are not classified as HIM or Secondary measures.
4. **ET (Emerging Technologies):** These are measures that are not included in utility portfolios currently.

The following data source priority structure was used in selecting energy and demand per unit savings values for all measure types and market sectors:

1. November 2011 DEER release
2. Energy Division (ED) vetted 2010-12 work-papers
3. CPUC 2006 -08 Evaluation Study (Cross checked with SPTdb)
4. DEER 2008
5. 2010 – 12 Work-papers not vetted by the ED
6. ASSET input values
7. Navigant calculations and secondary research

In the commercial sector, if per unit savings varied by building type, they were weighted to get a sector-wide average value. Details of this process are presented in Appendix M.

4.2 *Approach to Modeling Residential CFLs*

Savings from CFLs are impacted by the following factors:

» Based on the 2006-2008 evaluation, savings per unit are decreasing due to:

   a. Revised saturation, indicating that most remaining potential is in specialty CFLs

   b. Degrading operating hours, as lower use sockets account for a higher percent of installations

» The Huffman Bill, which phases in from 2009 through 2014, raises the residential lighting baseline for future years and thereby decreases the savings. Savings for non-specialty CFLs are zero starting in 2018.

Market Potential for Residential CFLs

The market potential estimated by this study for all residential CFLs was approximately 1,270 GWh in 2007 decreasing to 173 GWh by 2013. Potential declined over time as measure saturation occurs and average savings per lamps decreases and as codes reduce the number of lamps available for participation in utility rebate programs. Table 11 presents the market potential for indoor residential CFLs in the state of California by lamp type and shows the market potential for IOU incentive programs for integral, screw-in CFL lamps and fixtures decreasing to zero by 2018 as lighting efficacy standards relegate these devices to code[44]. The potential for specialty lamps will continue over time though will decrease as specialty CFL use approaches its maximum market saturation.

Table 11. Statewide Market Potential for Residential CFLs by Type (GWh)

Year	Specialty CFLs	CFL Fixtures	Screw-in CFLs	Total
2013	59	10	60	129
2014	69	15	21	105
2015	75	18	16	110
2016	78	20	10	108
2017	83	21	6	110
2018	83	0	0	83
2019	83	0	0	83
2020	84	0	0	84
2021	88	0	0	88
2022	89	0	0	89
2023	87	0	0	87
2024	90	0	0	90

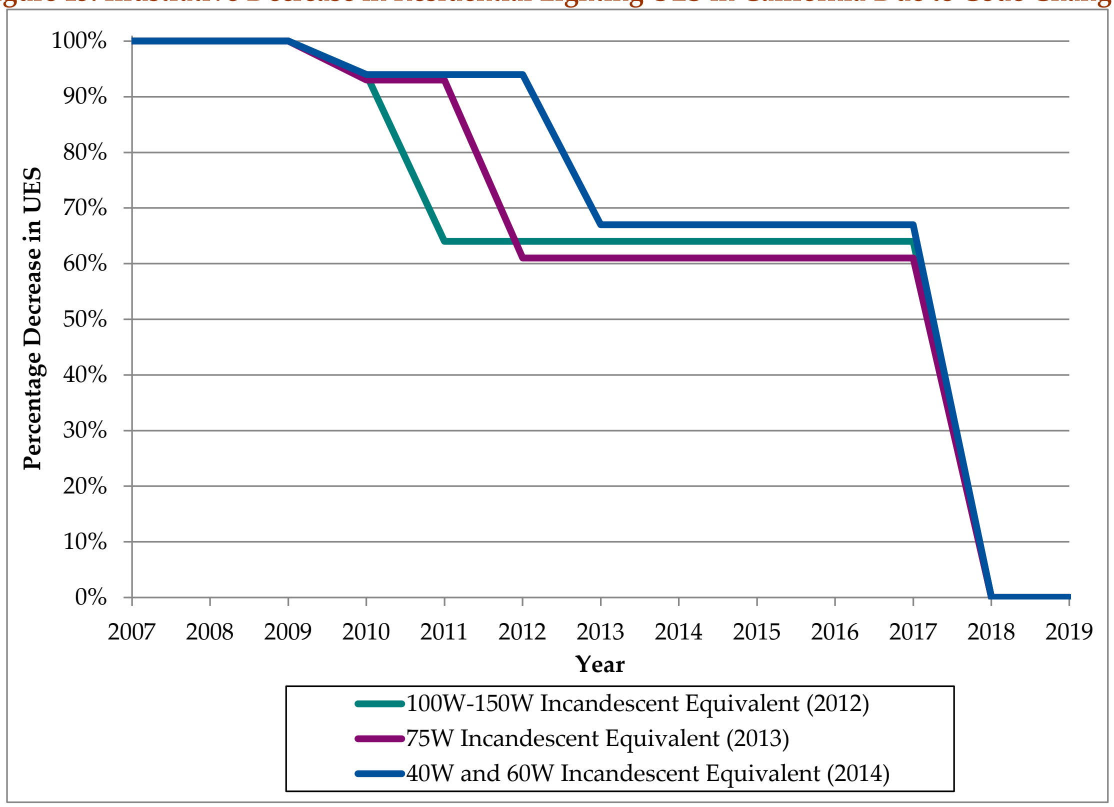
[44] The authors are aware that more efficient incandescent lamps are becoming available that may provide a baseline offering that meets code and allows some savings from standard CFLs lamps to remain. However it is uncertain if these lamps define a new baseline because it is not known how these lamps will be accepted in the market or if incremental costs to CFLs of the new lamps will be negative. Negative incremental costs can limit a measures ability to pass cost effectiveness test hurdles.

Table 11 illustrates a sharp decline in market potential in 2018. This is due to codes and standards changes for CFLs that come into effect that year.[45] Energy savings potential for specialty CFLs remains.

Codes and Standards Change

Title 20 code changes for lighting started coming into effect in 2009 and change codes through 2014. Due to these code changes, energy savings for all non-specialty light bulbs are calculated to be null. Figure 13 provides an illustrative view on how unit energy savings (UES) might change over time for lighting for different wattage levels of non-specialty CFLs.

Figure 13. Illustrative Decrease in Residential Lighting UES in California Due to Code Change*



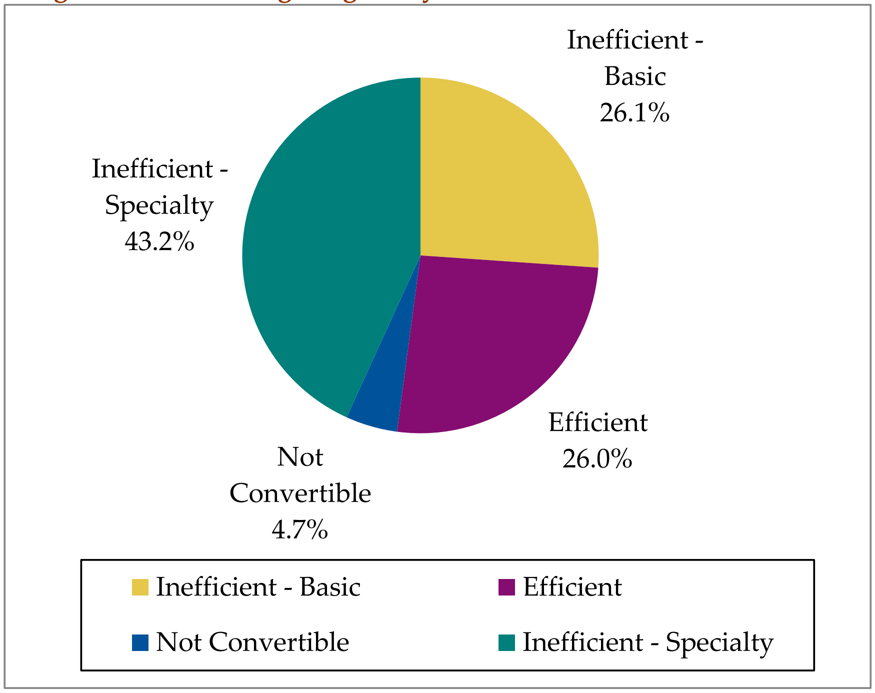
*Specialty CFLs are not represented in this graph.

CFL Hours of Use and Density:

To determine average hours of use and density for residential CFLs, the potential modeling team relied on residential CFL data collected by KEMA as a part of the 2006 -2008 CPUC evaluations. As a part of this study, data was collected from over 1,200 households on over 63,000 lighting sockets.[46] Figure 14 shows the results of socket characterization of all sockets surveyed.

[45] For more details on codes and standards changes, please refer to Section 3.3.3.

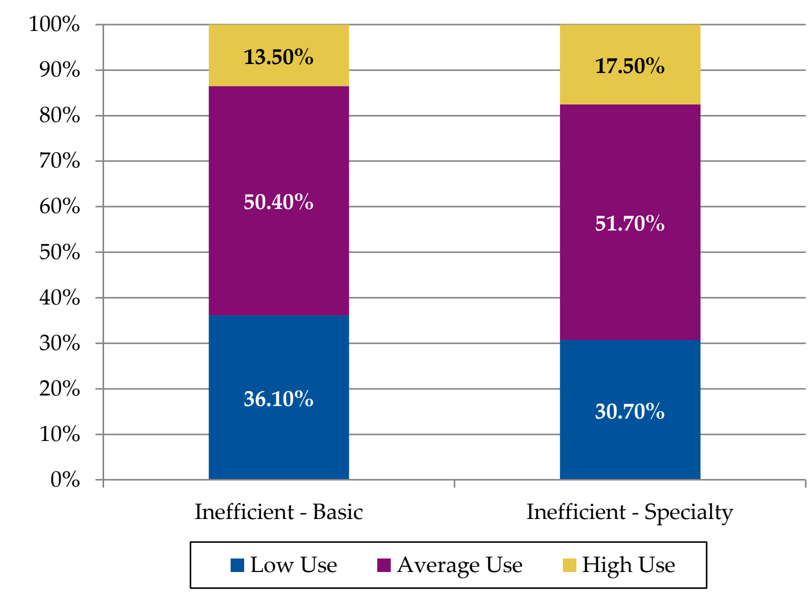
Figure 14. KEMA Lighting Study Socket Characterization Results[46]



Most of the energy savings potential from CFLs is represented by inefficient specialty lighting (43%) followed by inefficient basic or spiral lighting (26%). The majority of these sockets are either average or low-use sockets; most of the high-use sockets have already been converted to CFLs. This is presented in Figure 15.

[46] "Residential Lighting: Shedding Light on the Remaining Savings Potential in California," *IEPEC 2011:* Kathleen Gaffney, Tyler Mahone, and Alissa Johnson (KEMA Inc.).

Figure 15. HOU Bin Assignments by Type of Inefficient Socket[46]



Note: Overall, 26.1% of all sockets contain inefficient basic lamps and 43.2% contain inefficient specialty lamps.

Detailed tables presenting CFL density, hours of use, and per unit energy savings are presented in Appendix B.

Comparison with Previous Potential Studies:

The 2008 California potential study presented energy savings from residential lighting in 2016 for two scenarios:

1. Incandescent as baseline
2. CFL as baseline (Note: In this scenario, the 2008 potential study calculated lighting savings potential without CFLs as a measure to simulate the effect of the Huffman Bill.)

Table 12 presents a comparison of the technical and economic potential for residential lighting in 2016 as calculated by the 2008 and the 2011 studies. The 2011 study data presented represents indoor lighting only; its potential dominates outdoor lighting potential across technical, economic and market.

Table 12. Comparison of Residential Lighting Technical and Economic Potential Calculation in 2016 between 2008 and 2011 Potential Studies[47]

	Technical Potential – 2016		Economic Potential - 2016		Market Potential - 2016	
	2008 Study	2011 Study	2008 Study	2011 Study	2008 Study	2011 Study
Lighting	11,535	3,392	9,650	3,239	1,340	146
Lighting with CFL as Base	3,466	NA	1,581	NA	159	NA

Additionally, the 2011 potential study's calculated economic potential is approximately 36% of the potential calculated by the 2008 potential study. This is due to lower density and per-unit savings (based on lower hours of use) assumptions which are based on the KEMA lighting study.[48] Table 13 presents a sample comparison of density and savings assumptions in the PG&E service territory between the 2008 and the 2011 studies.

Table 13. Comparison of Density and Per Unit Savings Assumptions Made by the 2011 and 2008 Studies in the PG&E Service Territory

		2011 Study				2008 Study			
Measure Name	Building Type	Base Density	Efficient Density	Total Density	kWh Savings	Base Density	Efficient Density	Total Density	kWh Savings
CFL: <=7W Screw-In Indoor	SF	0.43	0.04	0.47	7.5	2.53	0.24	2.77	17.43
CFL: 13W Screw-In Indoor	SF	8.63	4.15	12.78	19.6	2.53	0.24	2.77	17.43
CFL: 18W Screw-In Indoor	SF	1.68	0.94	2.62	27.0	11.60	1.54	13.14	34.86
CFL: 23W Screw-In Indoor	SF	2.02	2.40	4.42	36.2	11.60	1.54	13.14	34.86
CFL: >25W Screw-In Indoor	SF	0.16	0.37	0.52	65.3	2.40	0.26	2.66	47.31
Single Family Total		***12.92***	***7.89***	***20.81***	**-**	***30.65***	***3.82***	***34.48***	**-**
CFL: <=7W Screw-In Indoor	MF	0.17	0.00	0.17	8.75	1.31	0.18	1.49	17.43
CFL: 13W Screw-In Indoor	MF	3.74	1.82	5.56	23.13	1.31	0.18	1.49	17.43
CFL: 18W Screw-In Indoor	MF	1.07	0.92	1.99	39.34	5.92	1.17	7.09	34.86
CFL: 23W Screw-In Indoor	MF	0.97	1.08	2.04	47.45	5.92	1.17	7.09	34.86
CFL: >25W Screw-In Indoor	MF	0.08	0.18	0.26	88.89	1.24	0.20	1.44	47.31
Multi-Family Total		***6.03***	***3.99***	***10.02***	**-**	***14.68***	***1.67***	***16.35***	**-**

<u>Conclusions:</u>

» The 2011 potential study uses residential lighting density and hours of use assumptions based on the KEMA Residential Lighting Study.[46]

[47] *"California Energy Efficiency Potential Study: CALMAC ID PGE0264.01 – Section 5.2.2,"* ITRON Inc. (2008).
[48] "Residential Lighting: Shedding Light on the Remaining Savings Potential in California," *IEPEC 2011:* Kathleen Gaffney, Tyler Mahone, and Alissa Johnson (KEMA Inc.).

» The majority of energy savings potential in the residential sector is from inefficient specialty sockets with average and low hours of use. This is followed by inefficient spirals with average or low hours of use.

» The 2011 potential study's estimate of technical potential are more conservative (by approximately 55%) than previous estimates as they take into account codes and standards changes that are expected to raise the baseline for residential lighting.

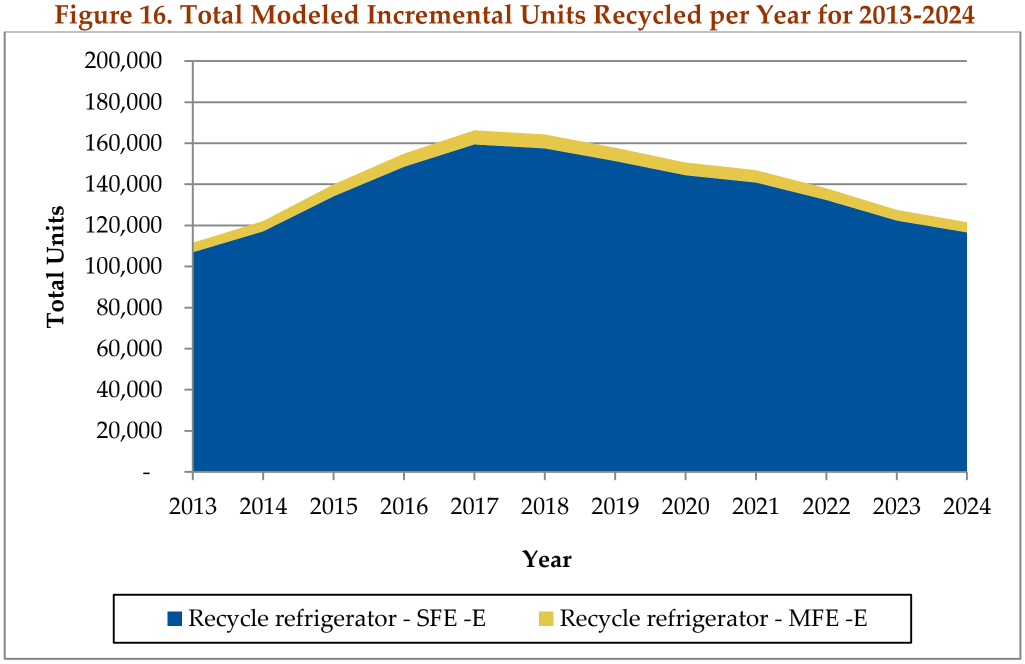
4.3 Approach to Modeling Appliance Recycling

Special considerations were taken when modeling refrigerator recycling measures. Refrigerator recycling programs need special treatment because of the unique characteristics of the base population. These unique characteristics include:

1. Unlike other base technologies, the used appliance stock available for recycling is constantly being refreshed with new populations of appliances.
2. Further, due to past improvements to appliance efficiencies (resulting primarily from codes and standards), the constantly refreshing population of available appliances for recycling is more efficient (and thus saves less energy) from year to year. Thus, available populations of appliances for recycling do not change significantly from year to year, but the time vector of savings per unit does decline.
3. Cumulative potential is adjusted to account for the fact that at the end of a measure life, the original participating refrigerators are no longer providing savings.

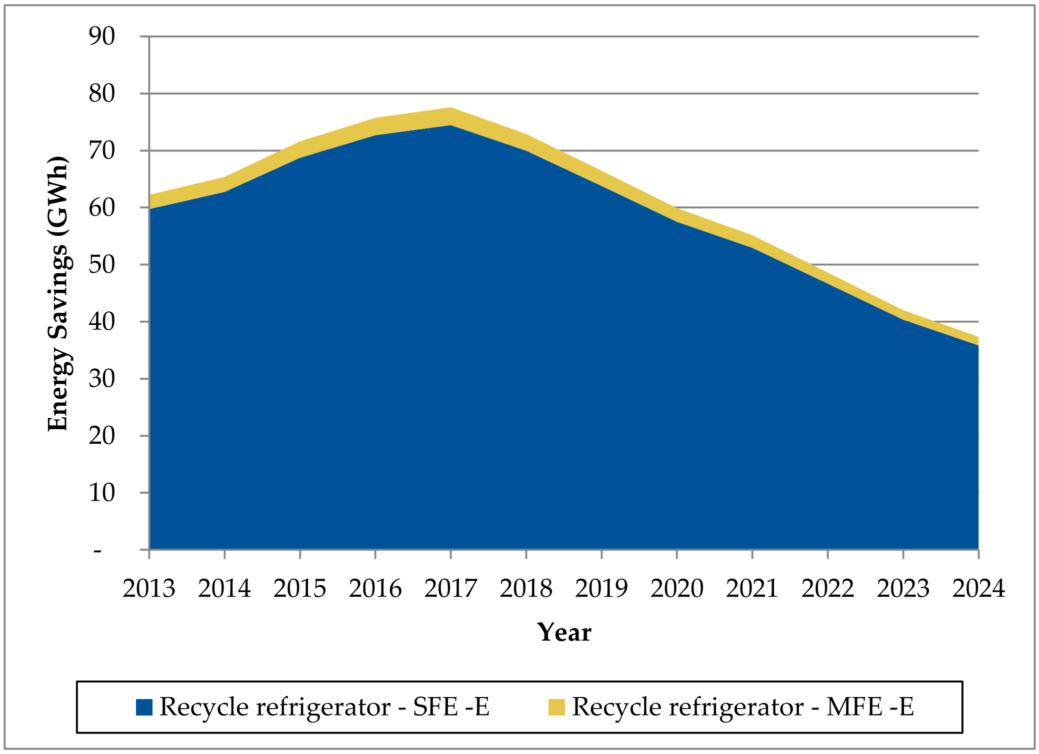
Figure 16 presents an estimate of refrigerators recycled annually in California through 2024. This number increases steadily until 2017 as the program becomes popular, and then gradually decreases. Due to a continually refreshing population, the measure does not get saturated. The decrease in units recycled after 2017 is due to the fact that per unit savings decrease and the measure becomes less cost effective, hence, reducing its popularity.

Figure 16. Total Modeled Incremental Units Recycled per Year for 2013-2024



As the per-unit savings decrease, the incremental energy savings potential decreases as well. This is illustrated in Figure 17 by the fact that incremental energy savings reduce at a greater rate than units sold post-2017.

Figure 17. Incremental Market Energy Savings Potential from Refrigerator Recycling



4.4 Approach to Modeling Emerging Technologies Energy Savings Potential

Navigant examined a set of emerging technologies as part of this study to forecast the potential impacts of the next generation of energy-efficient technologies. For the purposes of this project, emerging technologies are identified as those that meet the following criteria: 1) have less than 5% current market saturation, 2) are offered by at least one U.S. distributor, and 3) can be offered in utility programs in the next 3-5 years. One unique characteristic of ETs is that cost reductions or performance improvements are possible over the next 5-10 years. In total, Navigant examined 23 types of gas and electric emerging technologies (67 individual technologies in total) in the residential, commercial, and industrial sectors.[49] Navigant and knowledgeable staff from each IOU collaborated to determine this list of technologies through a selection and review process.

Navigant generated a preliminary list of emerging technologies by accessing its own internal databases as well as the Emerging Technology Program Database.[50] Through these databases, Navigant had access to over 800 possible emerging technologies across all fuel types and sectors. From this large selection, Navigant identified 90 technologies as "high potential" based on several metrics. These metrics can be

[49] In total 67 individual measures were characterized. Many of these measures are variations of the same base ET (e.g., different wattages and types of lamps, single-family and multi-family units).
[50] CPUC, Emerging Technology Program Database, January 2011.

seen in an illustrative scoring matrix in Table 14. The metrics were also used to initially rank these top 90 technologies and to narrow the list down to 20 "short-listed high potential" emerging technologies. The full list of 90 and the short list of 20 technologies were shared with IOU staff to inform the next step of the process.

Table 14. Illustrative Emerging Technology Scoring Matrix

Technology Assessment Scorecard						
Technology Characteristic	Weight	1	2	3	4	5
Energy Technical Potential	1	Low		Medium	High	
Energy Market Potential	2	Low		Medium	High	
Market Risk	1	(High Risk) • Requires new/changed business model • Start-up, or small manufacturer • Significant changes to infrastructure • Requires training of contractors Consumer acceptance barriers exist. • Long payback (e.g., >10 years)			(Low Risk) • Trained contractors • Established business models • Already in U.S. Market • Manufacturer committed to commercialization • Short payback period (e.g., <2 years)	
Technical Risk	1	High Risk: Prototype in first field tests	Low volume manufacturer Limited experience	New product (in any market) with broad commercial appeal	Proven technology in different application or different region	Low Risk: Proven technology in target application
Utility Ability to Impact Outcome	1	Private sector will be successful without utility involvement.	Utility is unlikely to be critical to adoption.	Utility is likely to accelerate adoption.	Utility is very important in accelerating adoption.	Utility is essential for catalyzing market.
Non-energy Benefits*	1	Few or none non-energy benefits	Some modest non-energy benefit likely	Significant benefits, difficult to quantify/not well understood	1 or 2 quantified, well-documented	Extensive, quantifiable, well-documented

IOU staff were provided the list of technologies to internally vet with their own emerging technology experts. A meeting was held with all IOU staff and Navigant staff to finalize the list and agree upon the final "top 20" technologies. As a result of this meeting process, approximately 10 of the original "short-listed high potential" items were removed from the list and replaced with technologies that the IOUs found more appropriate. After the draft report and results for this project were issued, Navigant, CPUC, and IOU staff determined several additional technologies should be added. The resulting final, IOU-approved list of technologies can be seen below in Table 15.

Table 15. Emerging Technology Selected for Study Inclusion

Technology Name	Description
LED Lighting – Residential and Commercial	LEDs are solid-state devices that convert electricity to light, potentially with very high efficiency and long life. Bulbs considered include standard bulbs to replace A19 type incandescent bulbs as well as PAR and MR style bulbs.
Hot/Dry AC	Commercially available air conditioners are designed for national performance standards

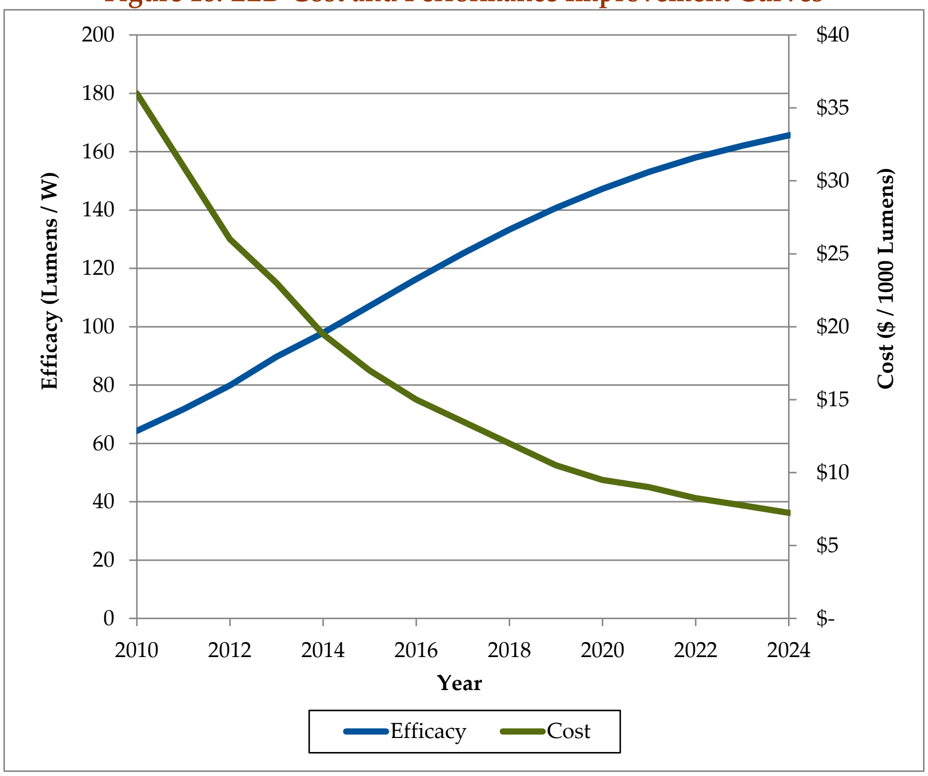
Technology Name	Description
Systems	roughly based on "average" cooling season weather conditions across the nation. The current design is not optimized for the weather conditions typical in California. As a result, energy is wasted by air conditioners in hot dry climates, particularly on peak days. Air conditioners are designed to remove moisture from the air (latent cooling) in addition to cooling the air (sensible cooling). In hot-dry climates, less latent cooling is needed. The sensible heat ratio is a measure of the amount of latent cooling an air conditioner performs. Nationwide, the average sensible heat ratios (SHR) range from 0.75 to 0.80. However, ideal hot-dry climate air conditioning equipment would have SHRs ranging from 0.90 to 0.95. Specialized hot-dry climate ACs would have higher SHRs decreasing energy use while maintaining sensible cooling ability
Evaporative Cooling	Evaporative cooling technologies accomplish all or part of comfort cooling by transferring sensible heat (hot, dry air) to latent heat (cooler, moist air) through the process of evaporating water at ambient temperatures. The efficiency and capacity of systems also tend to increase at higher outside temperatures while standard compressor-based systems become less effective at high outside temperature.
Indirect Evaporative Cooling	Indirect evaporative cooling uses evaporative cooling to cool a second stream of air that is used for space cooling (reducing interior humidity). Commercially available units range from 3 tons to 8 tons for residential and small commercial cooling.
Ductless Air Conditioning	Ductless split-system air-conditioners allow zone control in residential houses. Unlike a conventional forced air central air-conditioning system, the outdoor condensing unit provides liquid refrigerant to fan-coil units in each individual room. This eliminates supply and return ducts in the air distribution system (and the associated losses).
Water-Cooled Heat Exchangers for HVAC Equipment	New add-on water cooling devices are being developed for outdoor HVAC equipment. These devices spray water on the heat exchanging components of the HVAC units to improve heat transfer and thus reduce energy consumption.
Residential Night Ventilation Cooling	Night ventilation systems automatically ventilate houses using the normal air handler, supply, and return duct system, as well as a smart thermostat, mechanical damper, inlet and exhaust ducts. The smart thermostat monitors indoor and outdoor temperatures. When the outdoor temperature is lower than indoor, the system turns the air conditioning system off and ventilates the house with 100% outside air. Ventilation occurs throughout the night, exhausting the building mass and preparing the house for the next day.
Heat Pump Water Heaters	Electric heat pump water heaters (HPWH) extract low-grade heat from the air then transfer this heat to the water by means of an immersion coil. Electric HPWH have much higher efficiencies than conventional electric water heaters (e.g., EF> 2.5 vs. EF ~0.95).
Condensing Gas Water Heater	New designs of gas condensing storage water heaters have much higher efficiencies than conventional gas water heaters (e.g., EF> .82 vs. EF 0.60). Thermal efficiencies of 96% are claimed by manufacturers. New models on the market are the first models that meet 2012 Southern California low NO_x emissions standards.
LED for Street, Area, & Parking Lot Illumination	Existing covered parking lots and street lights are predominantly probe start metal halide (MH) or high-pressure sodium. LEDs offer improved efficiency and better lighting.
Improved Data Center Design	Improved data center design can consist of improved air flow design, centralized air handling systems, and variable CRAC compressors. Methods of improving airflow include hot aisle/cold aisle design, flexible barriers, ventilated racks, and optimized supply/return configuration. Centralized air systems use larger motors and fans, and can be more efficient than traditional designs. They are also well suited for variable volume operation through the use of Variable Speed Drives. Additionally, use of direct liquid cooling and efficient uninterruptible power

Technology Name	Description
	supplies can improve efficiency.
Improved Air-Flow Management	Air management for data centers entails all the design and configuration details that go into minimizing or eliminating mixing between the cooling air supplied to equipment and the hot air rejected from the equipment. When designed correctly, an air management system can reduce operating costs, reduce first cost equipment investment, increase the data center's density, and reduce heat-related processing interruptions or failures. Methods include hot aisle/cold aisle design, flexible barriers, ventilated racks, and optimized supply/return configuration.
Variable-Speed CRAC Compressors	Uncertainty regarding power densities of electronic equipment results in CRAC units that are frequently oversized. As a result, this equipment typically operates to remove extremely low heating loads. A way to improve the efficiency of CRAC units would be to fit them with variable-speed compressors.
Advanced Lighting Controls	In most office spaces, lighting has traditionally been designed to provide equal amount of light for all occupant spaces. New lighting control products allow individuals more flexibility in setting light levels for their spaces or automatic sensors to dim lights when spaces are not occupied.
Evaporator Fan Controller for Medium Temperature Walk-Ins	In conventional walk-in evaporator systems, the fans can run constantly whether the temperature set point is satisfied or not. This measure works by cycling the evaporator fans when the compressor is cycled off and there is no refrigerant flow through the evaporator.
Combined Space and Water Heater	Combines water heating with hydronic space heating or hydro-air system. Reducing equipment required and increase efficiency by capturing more heat from combustion gasses.
Advanced HID Lighting - Pulse Start and Ceramic Metal Halide	High-Intensity Discharge (HID) lights are commonly used in outdoor applications such as street lighting and parking garages. HID lamps use an electrical arc column across tungsten electrodes to produce light. About 57% of the electric power that penetrates the arc column escapes as heat, and 33% is utilized to produce visible light. Advanced HID lamps would shift some energy (infrared) from the arc to near UV or visible emission, improving efficiency.
Fault Detection and Diagnostics	Fault detection diagnostics (FDD) monitors equipment operation and notifies users of faults or performance degradation so that they can be corrected quickly and catastrophic failures can be avoided.
Variable Refrigerant Flow	Variable Refrigerant Flow (VRF) systems are fundamentally different from unitary or other types of traditional HVAC systems. The space is cooled or heated directly by circulating refrigerant to evaporators located near or within the conditioned space.
Advanced Steam Trap Systems	Attaching advanced automated monitors to steam traps allows for the quick diagnosis and correction of steam trap malfunction. This measure can lead to energy savings beyond the energy savings achieved through regular steam trap maintenance.
Reduced Working Temperature for Asphalt	Warm mix asphalt pavements can be produced at temperatures as much as 100°F lower than traditional methods, with an associated fuel consumption savings. There are at least four competing processes in various states of development that enable asphalt to be worked at lower temperatures.
High Performance Rooftop Unit	Rooftop units that meet the DOE and the Commercial Building Energy Alliances (CBEAs) new design specification for high-performance rooftop air conditioning units (RTUs).
Comprehensive Commercial HVAC Rooftop Unit Quality Maintenance	An inspection of rooftop HVAC units by trained HVAC contractors to identify performance improvements. Possible maintenance actions include: refurbish degraded ducts, restore and improve duct system insulation, duct sealing, coil cleaning, replace air filter, TXV attachment and insulation correction, and refrigerant system test and charge adjustment. Actual actions implemented vary by customer, though typical savings have been documented.

After agreeing upon this list, Navigant collected data to characterize these technologies. The IOUs responded to data requests from Navigant by providing work papers, case studies, engineering studies, and draft analyses available for the selected emerging technologies. In some cases utility data was not available and Navigant conducted additional research from sources which included manufacturer case studies, third-party case studies, DOE and CEC data, and Navigant's engineering expertise. The results of this analysis are illustrated in Appendix M for the PG&E service territory. Specific analysis for each IOU service territory was conducted; however, only PG&E data is displayed here for simplicity.

Note that savings and cost are only listed for 2011 values. Navigant expects LED technology to improve (in both efficacy and cost) over time. While Appendix M only displays a snapshot of the technology at the current time, Navigant did develop and incorporate performance improvement curves and cost reduction curves (illustrated in Figure 18) into the potential study model.

Figure 18. LED Cost and Performance Improvement Curves



Source: Efficacy Curve obtained from Navigant[51]; cost curve obtained from Bloomberg[52]

4.4.1 Comparison of Emerging Technology Measures to the 2008 Potential Study

The 2008 goals and potential study incorporated a limited number of emerging technologies. Those that were included were classified as Current Emerging Technologies (CETs). CETs were defined as "measures (that) are currently available in the market, but are new to the marketplace. These

[51] Navigant, *Energy Savings Potential of Solid-State Lighting in General Illumination Applications 2010 to 2030*. Prepared for the U.S. Department of Energy, February 2010.

[52] Bloomberg, *LEDS: The Energy Efficiency Game Changer*, New Energy Finance Summit, 2011.

technologies are associated with a higher level of uncertainty associated with their performance, costs, and the likelihood of consumer acceptance of the measures."

Five CETs were included in the 2008 potential study while 23 are included in this update study. The 2008 potential study technologies are listed below in Table 16 along with their descriptions and the corresponding measure that appears in this updated study.

Table 16. Emerging Technology Comparison

2008 Study Measure Name	2008 Description	Corresponding 2011 Study Measure
	Commercial	
Night Economizer, Current Emerging Technology	This measure is modeled as an RET decision type. A night economizer system is similar to a whole-house fan in that it brings outside air inside when the outside air temperatures are lower than the indoor temperature, as is often the case during mornings, late evening, and nights. The night economizer as modeled reflects the use of a smart thermostat, mechanical damper, and inlet and exhaust ducts to automatically ventilate the house with 100% outside air when outdoor temperatures are below indoor temperatures.	Residential Night Ventilation Cooling (ET)
Cool Roof, Current Emerging Technology	This measure is modeled as an ROB decision type. Cool roof coatings reduce the roof temperatures and thereby reduce the solar thermal loads on the building. This measure is only applicable to cooling-predominant climates and homes that use compressor-based cooling systems (i.e., not evaporative coolers). Cool roof for residences is considered a CET because applying cool roofing material to the residential sector is a new application of a technology more commonly used in the commercial sector. With the new application, the incremental costs, savings, and customer likelihood of adoption are more uncertain.	Not Included
LED Reflector, Current Emerging Tech	This measure is modeled as an ROB decision type. Some versions of R20 LED reflector lamps are currently available in the marketplace but at much higher cost relative to either the CFL or incandescent base technologies; an R20 LED lamp is modeled to cost $34 per lamp compared to $8.5 for the R30/R40 reflector. There are also a few remaining unresolved technical issues for LED reflectors; for example, the light output of LED downlights is significantly less than incandescent or CFLs, and the LEDs generate a lot of heat. For comparison, R20 CFL lamps are 9-11 W and R20 incandescent lamps are 65 W.	LED Lighting Standard, PAR, and MR (ET)
LED Christmas Lights, Current Emerging Tech	This measure is modeled as an ROB decision type. LED holiday lights use just one-tenth the energy of incandescent holiday lights. They are widely available online, as well as at hardware stores, home improvement stores, and major retailers, but still carry a large cost premium compared to incandescent holiday lights.	LED Holiday Lights (Conventional)
Commercial		
Gas Space Heating Boilers 95% - Current Emerging Tech	This measure is modeled as an ROB decision type. Standard efficiency natural gas furnaces have an Annual Fuel Use Efficiency (AFUE) of 78% as regulated by Title 20/NAECA standards, although standard practice is 80% AFUE. Efficiency is dependent on event type, burner type, furnace type (conventional or condensing), and fan control type. The AFUE for the base unit is 80% (to reflect standard practice) and the minimum AFUEs for the energy-efficient units are 92%, 94% as reflected in the TechID and Measure.	Space Heating Boiler 95% Efficient (Conventional)

4.5 *Approach to Modeling Behavior-Based Energy Savings Potential*

Savings potential from behavior-based initiatives was included in the EERAM model. For the purposes of this study, Navigant defines behavior-based initiatives as those providing information about energy use and conservation actions, rather than financial incentives, equipment, or services. These initiatives use a variety of implementation strategies including mass media marketing, community-based social marketing, phone calls, home visits, competitions, training, and feedback.[53]

Outcomes from behavior-based initiatives that result in energy savings can be broadly characterized as equipment-based and usage-based:

- **Equipment-based behavior –** Purchase and installation of higher efficiency equipment, relative to baseline conditions.[54] Examples of equipment-based behavior include the replacement of lights with higher efficiency lights, purchasing ENERGY STAR-qualified appliances, and purchasing premium efficiency motors. In the EERAM Model, these savings are modeled implicitly at the equipment level as contributions to the percentages of the population that are aware of the measure and that are willing to adopt this measure.

  Equipment-based behavior can be sub-categorized as:

  - **Non-incented equipment-based behavior** – The purchase of higher efficiency equipment for which no incentives are provided.
  - **Incented equipment-based behavior**– The purchase of higher efficiency equipment for which incentives are provided. Also known as “channeling”.

- **Usage-based behavior** – Changes in usage and maintenance of existing equipment. Examples of usage-based behavior include turning off lights, unplugging electronics and chargers, programming thermostats, and improving the efficiency of equipment through modified maintenance practices. In the EERAM model, these savings are modeled as an equipment-independent module with savings unassociated with equipment improvement.

The following subsections describe the modeling of residential and commercial behavior-based potential, discuss data gaps, and identify areas for modeling improvements.

4.5.1 Residential Behavior

Navigant found that feedback program evaluations provide the most rigorous residential behavior savings estimates available. Feedback programs provide energy use information to participants in the form of reports, online audits, or in-home displays. We focused on these programs because implementers can broadcast these programs widely and can implement them with experimental design that enables the precise estimation of impacts.[55] For this study, Navigant narrowed its research to home energy report programs and similar feedback report programs that provide periodic information to participants on their home energy use as well as the energy use of other homes in their area.

---

[53] For further discussion, see *Evaluation of Consumer Behavioral Research*, Navigant (Summit Blue Consulting) for the Northwest Energy Efficiency Alliance, April 6, 2010, page 4.

[54] This could be either the early retirement of older equipment or the installation of high-efficiency equipment at the natural time of installation or replacement.

[55] Impacts are typically on the order of two percent per household. Key components of proper experimental design for these types of programs include randomly selected control and experimental groups and large sample sizes (i.e., tens of thousands of households in each group).

Navigant identified seven recent evaluations covering approximately 15 different feedback programs. Across programs, the average household energy reduction ranged from 1.1% to 2.9% of total household consumption per household and averaged 2.3% across all of the evaluations.[56] Upon discussion with the IOUs regarding expected savings from their pilot home energy report programs, we used slightly lower estimates of savings to reflect longer term (i.e., more than one year) participation and SDG&E's lower expected impacts due to the relatively low residential space heating and cooling loads in their territory. Table 17 summarizes the impact assumptions:

Table 17. Per Household Residential Behavior Impacts

Fuel Type	PG&E, SCE, and SCG	SDG&E
Electric	1.8%	1.5%
Gas	1.25%	0.9%

Source: Navigant Consulting, 2012

Evaluators used whole-house billing data analysis to develop these estimates; while they are precise difference-in-difference estimates of impact at the whole-house level, they cannot identify the specific outcomes that lead to these impacts. That is, this analysis approach cannot differentiate between impacts from individual actions such as turning off appliances, turning down thermostats, or replacing inefficient equipment. Thus, these estimates, derived from billing-analysis-based impact evaluations, could not provide the granularity necessary for the EERAM model: the portion of impact from usage-based behavior and portions of impact from specific equipment-based behaviors.

In order to disaggregate per household savings into equipment-based and usage-based savings, Navigant searched for relevant impact studies that identified the types of behaviors that make up reported savings. Unfortunately, no studies have estimated disaggregated impacts.[57] Lacking empirical evidence, Navigant relied on discussions with utility staff running home energy report programs to estimate this disaggregation. Based on these discussions, Navigant assumed that 67% of impacts are usage-based and 33% are equipment-based.

Our approach to estimating the savings potential from behavior programs has two significant shortcomings. Accurate estimates of disaggregated impact (usage-based, equipment-based) are unavailable, yet needed to avoid double-counting of potentials from equipment modules and the usage-based behavior module. Also, we modeled behavior-based potential on a specific type of behavioral program, while many more types of behavioral programs are in-place or possible.

Two examples from our research illustrate the shortcomings in our approach and need for further primary and secondary research. First, equipment-based outcomes do not necessarily represent a significant portion of savings: During the California energy crisis of 2000-2001, a 7% reduction in peak demand was observed across the state. A survey of California residents found that the large majority of

[56] non-weighted average

[57] Disaggregated *outcomes* have been studied. Navigant identified one Home Energy Report impact evaluation[57] that examined this disaggregation effectively. In addition to billing analysis, the study included surveys of the control and experimental group members that asked what conservation actions the households had taken. The study found that equipment-based actions were the majority of actions for which the experimental group self-reported statistically significant higher rates of activity. However, the evaluation did not translate these reported actions into impact estimates.

actions taken by households to reduce demand at that time were behavior-based, not equipment-based.[58] While the circumstances of this conservation behavior were extraordinary, the findings do illustrate that – at least for short periods of time – savings could come largely from usage-based behavior changes.

Second, behavior programs with different delivery mechanisms can have a variety of impact patterns. For example, the PG&E Home Energy Efficiency Survey program[59] offers households a home audit and a personalized set of recommendations for saving energy. In order to model the willingness of households to implement this measure, we would need the participation rates (i.e., percentage of marketed pool of customers that participates), yet the studies that we reviewed do not report this information. Without this information, we cannot extrapolate observed impacts to the statewide population. The study could only attribute about 20% of the impacts estimated from the self-reported actions of participants to the program; this emphasizes that opt-in behavior programs often encourage behavior change to an already conservation-minded demographic.

Scaling the per-household potential from residential behavior programs up to an IOU territory level proved challenging for several reasons:

- Multiyear persistence of savings has not been studied; it is unclear whether or not it is effective for households to "reparticipate" each year.
- Several groups of households should not be included in the potential:
    - New residents (Approximately 15% of residents move each year[60]) and other customers for which valid neighbor comparisons cannot be generated
    - Customers on medical baseline rates
    - Customers who have opted out of receiving marketing materials
    - Customers in regions that utilities have decided to exclude from programs due to customer satisfaction concerns
    - A substantial control group should be set aside in order to verify savings.

For these reasons and the IOUs' need to learn more about the impacts of these programs through gradual roll-out and evaluation of programs, we have set the potential and target levels of penetration for behavior programs relatively low: 2.5% of households in 2013, and 5% of households for 2014 through 2024.

4.5.2 Commercial Behavior

Navigant identified relevant data for behavior savings in the commercial sector via a literature review of potential studies and impact evaluations. We placed emphasis on impact evaluations of Building Operator Certification (BOC) programs, which offer energy efficiency training and certification courses to commercial building operators in the commercial sector. We reviewed these programs because of their demonstrated energy savings across numerous program evaluations. Several of these studies

[58] Loren Lutzenheiser, "Lasting Impressions: Conservation and the 2001 California Energy Crisis," Portland State University. 84% of self-reported actions taken were usage-based. However, the evaluation did not translate these reported actions into impact estimates.
[59] ECONorthwest, "Process Evaluation of the PG&E 2006-2008 Home Energy Efficiency Survey (HEES) Program," 2010.
[60] PG&E estimate provided for this study.

disaggregated impacts as equipment-based and operation and maintenance- (usage) based. Appendix C provides a full list of reviewed literature.

As with the residential behavior programs, the EERAM model implicitly includes equipment-based commercial building potential within each equipment module, as an incremental increase to measure awareness and willingness to adopt. The usage-based impacts from these programs are then modeled as an additional module.

Navigant reviewed four BOC program evaluations and identified the average usage-based annual savings per 1,000 square feet to be 410 kWh and 19 therms. Of these savings, usage-based activities (i.e., operations and maintenance [O&M] practices) accounted for 41 kWh and 5.6 therms (per 1,000 square feet, per year). Improved O&M practices mostly fell into the following categories:

» Improved air compressor operations and maintenance

» Improved HVAC operations and maintenance

» Improved lighting operations and maintenance

» Improved motors/drives operations and maintenance

» Water conservation resulting in energy savings

» Adjusted controls of HVAC systems

» Adjusted controls of energy management systems

However, the sample sizes of these studies were not large enough to estimate the program-wide impacts of individual action types. Therefore, the studies used only the aggregate usage-change values.

The most significant shortcoming of our treatment of non-residential behavior-based potential is that we only had data to support the modeling of programs geared towards the building operator. Additional potential likely exists from building-user-based behavioral initiatives (e.g., office energy captains).

4.5.3 Considerations for Future Studies

A scarcity of impact data presents the most significant weakness with the current representation of the potential from behavior-based initiatives. The potential model could benefit from additional primary and secondary research to identify the impacts of a broader range of behavior-based initiatives, both currently in use and potentially deployable. Within these initiatives, the model would benefit from a more granular understanding of actions taken, from which load shapes and measure persistence could be estimated.

The following are open research questions that contribute to the long-term uncertainty in estimating potentials from both residential and commercial behavior-based programs:

» What are the specific actions (or action categories, such as usage-based actions, equipment-based actions) that result in impacts from behavior-based programs, and what are the impacts of these actions?
» What is the action-specific persistence of savings, both in the continued presence of a program and after a participant stops receiving information?
» What is the overlap in savings between those attributed to a behavior program and those achieved through incentive programs that are not tracked at the site level (e.g., upstream CFL programs)?

» To what extent are equipment-based savings capturing a new market segment, and to what extent are they accelerating the adoption of equipment that would have occurred in the absence of the behavior program?
» What are the feasible levels of program participation, and the rates at which programs should ramp up to these levels?

Until this topic is more thoroughly characterized and modeled, the potential impacts from behavior-based initiatives will be largely difficult to accurately assess.

4.5.4 Approach to Modeling the Low-Income Sector Energy Savings Potential

As indicated in Table 18, nearly one in three California households qualifies for the California Alternate Rates for Energy (CARE) and the Low-Income Energy Efficiency (LIEE) programs. The Navigant study modeled savings potential for the low-income (LI) market based on savings estimates provided by the IOUs and the 2007 Low-Income Needs Assessment (LINA).[61] The Needs Assessment provided the following insights:

» Estimated total low income energy use in California is 22,000 GWh and 1,300 Mth.

» Total potential electricity savings is estimated at 641 GWh and natural gas savings potential is estimated at 94 million therms.

» Savings potential for households who are willing to participate in the LIEE Program are estimated at 584 GWh (91% of total potential) and 81 million therms (90% of total).

» Average savings potential per home is estimated to be 150 kWh and 22 therms.

EERAM estimates approximately 208 kWh of potential per home and 9 therms of market potential per household (HH) in 2013, which is significantly less than the them potential indicated in the Needs Assessment indicates. Table 19 provides the 2011 potential study estimates of technical and economic potential per single family/multifamily and low income household as modeled in 2013. The 2011 potential study assumes that all potential in the low-income sector is market potential. Appendices E-H provide a more detailed view of the assumptions and inputs by IOU used to estimate potential for low-income households. .

Table 18. Percent of California Households Eligible for Low-Income Energy Assistance

Utility	Total Households	Eligible Households	Participating CARE Households	% of Total Households that are Eligible Households	% of Total Households Participating in CARE
SCE	4,341,086	1,444,199	1,380,670	33%	32%
SCG	5,338,157	1,837,355	1,707,036	34%	32%
PG&E	5,469,228	1,699,660	1,490,577	31%	27%
SDG&E	828,073	235,841	197,259	28%	24%
Total	15,976,544	5,217,055	4,775,542	32%	29%

[61] KEMA, Phase 2 Low Income Needs Assessment, California Public Utilities Commission Final Report, September 7, 2007.

Table 19. Forecast Potential per Household 2013

Year	Avg. Consumption, (all Household types, kWh)	Technical Potential (kWh)	
		Per SF/MF HH	Per LI HH
2013	7,067	1,585	208

4.6 Approach to Modeling New Construction Energy Savings Potential

4.6.1 Approach to Residential New Construction

This section provides a summary of the residential new construction analysis.

4.6.1.1 Overview and Background

For the 2011 potential study we built upon the approach of the 2008 potential study but with a modified methodology, as explained below. The 2008 potential study estimated the potential energy savings from constructing low-rise residential buildings that were designed and constructed to be 15% and 25% higher than code. The 2008 potential study built on the previous 2006 potential study.[62]

The 2008 potential study estimated energy efficiency potential for residential new construction by building type and climate zone, created packages of high-efficiency measures that represented 15% and 25% savings, and developed incremental costs for several scenarios for alternative levels of measure incentives and costs. The savings were calculated using actual houses, not prototype models.

4.6.1.2 Approach and Results

To estimate energy savings potential in this study, we used the measures and technologies proposed for the 2013 Title 24 (Part 6) building energy codes update. In order to meet the EE Strategic Plans stated goals of zero net energy residential buildings by 2020 and nonresidential buildings by 2030, the CEC target is a 15%+ improvement over the existing code in each code cycle.

Energy Savings were estimated for three levels compared to 2005 Title 24 Baseline:

» Level 1 15%: defined as the 2008 Title 24

» Level 2 25%: defined as the proposed 2013 Title 24, Part 6 base code

» Level 3 30%: defined as the proposed 2013 Title 24, Part 11 reach code (Tier 1)

Savings are expressed as savings per prototypical home, as described below. Savings were initially calculated by climate zone and subsequently rolled into utility service territory specific savings.

[62] "California Energy Efficiency Potential Study,": ITRON, KEMA (2006). CALMAC ID: PGE0211.01.

Level 1 – 15% Savings over 2005 Title 24

Level 1 energy savings and costs were taken from the CEC's Impact Analysis 2008 Update to the California Energy Efficiency Standards for Residential and Nonresidential Buildings prepared by AEC, November 7, 2007.[63]

The impact of implementing the residential envelope, HVAC, and water heating measures of the 2008 Standards as compared to the 2005 Standards was estimated using a prototype approach. The single-family prototype was made to minimally comply with the 2005 and 2008 Standards. The changes to the Standards (2005 to 2008) that are assumed to result in savings are:

» Residential Fenestration: The fenestration requirements are lower U-factor and solar heat gain coefficient (SHGC). The U-factor was reduced to 0.40 Btu/(hr x ft2 x deg F) in all climate zones from 0.57 Btu/(hr x ft2 x deg F) in climate zones 1-2, 10-15 and from 0.67 Btu/(hr x ft2 x deg F) in climate zones 3-9 and 0.55 Btu/(hr x ft2 x deg F) in climate zone 16. SHGC was reduced from 0.40 to 0.35 in climate zone 15 and was changed from 'not required' to 0.40 in climate zones 5 and 6. SHGC is the ratio of the solar heat gain entering the space through the fenestration area to the incident solar radiation.

» Cool Roofs: Requires cool roofs with a minimum aged reflectance of 0.25 in climate zones 10,11,13,14, and 15. The default aged reflectance is 0.08. Solar Reflectance is the ratio of the reflected solar flux to the incident solar flux. Aged solar reflectance is the ratio for a cool roof that has been exposed to the elements for three years and thus has a lower reflectance than the same product when initially installed.

» Residential Indoor Air Quality (IAQ) Ventilation: This measure requiring mechanical ventilation adopts requirements of American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) 62.2-2007, requiring that residential buildings have mechanical ventilation, such as a whole-house exhaust, or ducted supply system.

To provide average energy and demand savings per single-family (SF) home for the EERAM model, we calculated savings by dividing total savings by house starts. The resulting first-year electricity and gas and savings are shown in the last three columns of Table 20.

[63] http://www.energy.ca.gov/title24/2008standards/rulemaking/documents/2007-11-07_IMPACT_ANALYSIS.PDF

Table 20. Level 1 (15%) Average Statewide Savings per Single-Family House

Climate Zone	SF Housing Starts	Total Energy and Demand Savings			Average Savings per SF house		
		Electricity (MWh)	Demand (MW)	Gas Savings (Therms)	Electricity (MWh)	Demand (MW)	Gas Savings (Therms)
1	422	47	0.02	3,759	111	0.05	89
2	2,351	738	0.33	19,245	314	0.14	82
3	3,486	355	0.46	29,566	102	0.13	85
4	3,081	414	-0.09	29,923	134	-0.03	97
5	996	261	1.22	1,676	262	1.22	17
6	3,103	920	3.92	1,119	296	1.26	4
7	2,805	(87)	0.1	13,535	(31)	0.04	48
8	4,454	542	0.17	22,561	122	0.04	51
9	4,226	1,212	0.91	21,867	287	0.22	52
10	18,661	12,828	4.75	79,886	687	0.25	43
11	6,433	5,855	1.88	55,045	910	0.29	86
12	18,641	10,587	4.03	147,352	568	0.22	79
13	14,095	17,879	3.47	85,707	1,268	0.25	61
14	12,300	14,328	4.99	107,981	1,165	0.41	88
15	9,472	30,142	6.64	16,882	3,182	0.70	18
16	3,494	1,891	0.66	48,352	541	0.19	138
Total	108,020	97,912	33.46	684,456	9,920	5.37	1,036

Level 2 – 25% Savings over 2005 Title 24

Level 2 savings and costs were estimated based on the 2013 Codes and Standards Enhancement (CASE) reports, completed by the IOUs, and submitted to the CEC in September 2011. The 2013 code update represents a 20%+ improvement over 2008 Title 24 in terms of source energy savings though the savings vary by climate zone. Because utility new construction incentive programs are designed to ready the market for the next code cycle, using the 2013 code proposals to represent current (2010/2011) new construction program measures and opportunities is a logical approach. The 2013 code update savings and associated incremental costs are documented in CASE reports submitted to the CEC by the IOUs.

Level 2 measures include the following:

- Ceiling and roof deck insulation
- Radiant barrier
- Cool roof
- Wall insulation
- Windows
- Quality Insulation Installation (QII)
- Duct insulation

- Reduced infiltration
- Reduced duct leakage/tighter ducts
- Whole-house fan
- High-efficiency air conditioner
- High-efficiency furnace
- High-efficiency water heater
- Water heater pipe insulation

The Level 2 measures result in per single-family house savings and associated costs as shown in Table 21.

Table 21. Level 2 (25%) Average Statewide Savings per Single-Family House

Climate Zone	kWh	kW	Therms	Added Cost
1	187.26	-	69.38	$ 2,159
2	299.10	0.32	78.48	$ 2,415
3	156.88	0.15	62.68	$ 2,004
4	369.64	0.64	49.78	$ 1,759
5	217.99	-	147.58	$ 2,004
6	294.42	0.54	39.52	$ 2,041
7	202.78	0.47	27.34	$ 2,041
8	530.73	1.17	32.58	$ 2,335
9	890.37	1.60	41.06	$ 3,364
10	1,000.59	1.66	54.85	$ 3,820
11	1,298.44	1.59	78.41	$ 3,820
12	867.21	1.55	78.04	$ 3,820
13	1,356.77	1.45	73.96	$ 3,820
14	1,094.66	1.31	60.56	$ 3,564
15	1,907.42	1.55	31.55	$ 3,613
16	816.36	1.45	(14.11)	$ 2,159

Level 3 – 30% Savings over 2005 Title 24

Level 3 savings and costs were estimated based on the 2013 CASE reports, completed by the IOUs, and submitted to the CEC in September 2011. For the residential new construction program, we were able to use the California Reach Standards (Title 24, Part 11) to represent a 30% improvement over the base (2005 Title 24). The 2013 Reach code, which can be implemented by local jurisdictions as part of CALGreen, represents a 15%+ improvement over the base 2013 Title 24 (Part 6) requirements. The Level 3 measures result in per single-family house savings and associated costs as shown in Table 22.

Table 22. Level 3 (30%) Average Statewide Savings per Single-Family House

Climate Zone	kWh	kW	Therms	Added Cost
1	266.66	-	154.87	$ 4,953
2	407.88	0.41	163.76	$ 5,414
3	228.61	0.17	137.33	$ 5,503
4	406.87	0.95	140.18	$ 5,954
5	296.24	-	232.49	$ 5,660
6	366.33	0.63	84.81	$ 5,544
7	240.54	0.54	44.06	$ 4,476
8	679.43	1.56	67.68	$ 5,839
9	1,073.47	1.96	80.66	$ 5,954
10	1,183.38	1.96	91.44	$ 5,754
11	1,566.56	1.85	115.25	$ 5,853
12	981.24	1.72	116.53	$ 5,303
13	1,658.38	1.74	105.71	$ 5,853
14	1,300.19	1.53	95.50	$ 5,446
15	2,083.06	1.78	34.65	$ 4,906
16	949.33	1.55	89.21	$ 4,924

4.6.1.3 *Rollup savings to IOU territory*

We converted the savings expressed as savings per home by climate zone to savings per home by utility territory for the EERAM model using the following methodology. The CEC climate zones were first mapped to CEC forecast zones using information available from the California Energy Commission forecast. The forecast climate zones were then mapped to utility territories using a forecast zone to zip code mapping. Thus, each CEC climate zone was mapped to one or more utilities based on the number of zip codes served by each utility. Since this study is limited to the IOU programs, the areas/zip codes not served by IOU were excluded from the mapping exercise; thus, the total of savings for all IOU combined is less than the total for all climate zones in the tables above.

4.6.2 Approach to Commercial New Construction

This section provides a summary of the nonresidential new construction analysis.

4.6.2.1 *Overview and Background*

The approach used for commercial new construction borrows from and builds on the 2008 potential study. The 2008 potential study estimated the potential energy savings for nonresidential buildings that were designed and constructed to be 15% and 25% higher than base code to represent buildings that met the requirement of the non-residential new construction program (Savings by Design).

The 2008 potential study estimated energy efficiency potential for nonresidential new construction by building type and climate zone, created packages of high-efficiency measures that represented 15% and 25% savings, and developed incremental costs for several scenarios for alternative levels of measure incentives and costs. The savings were calculated using a large number of individual buildings rather than defining a set of prototype models. The analysis was conducted for 11 building types: colleges, grocery stores, health care buildings, lodging, large office buildings, retail, restaurants, schools, small office buildings, warehouses, and miscellaneous.

4.6.2.2 Approach and Results

Energy Savings were estimated for two levels compared to 2005 Title 24 Baseline:

- Level 1 15%: defined as the 2008 Title 24
- Level 2 25%: defined as the proposed 2013 Title 24, Part 6 base code

Savings are expressed as savings per square foot. Savings were initially calculated by climate zone and subsequently rolled into utility service territory specific savings.

Level 1 – 15% Savings over 2005 Title 24

The 15% above 2005 Title 24 estimates from the 2008 potential study were used for the Level 1 energy savings and incremental costs. Because Level 1 represents current code (implemented in 2010), the actual savings potential from the new construction program is zero. For this reason, the team assumed that the existing estimates are valid and no further refinement was warranted for this update analysis.

The Level 1 measures result in the per-square-foot savings and associated costs as shown in Table 23. Measures designed as “load avoidance” strategies, such as efficient lighting, high-performance glazing, cool roofs, and demand-controlled ventilation, can reduce the peak cooling loads and size of the mechanical systems. The cost savings resulting from downsizing HVAC systems were included in the 2008 potential study and in some climate zones completely offset or exceeded the incremental costs of the measures, as indicated by a negative number in the incremental cost column.

Table 23. Level 1 (15%) Average Statewide Savings

Climate Zone	Savings per Sq Ft: Electric Savings (kWh)	Savings per Sq Ft: Gas Savings (Therms)	Incremental Cost per Sq Ft
1	2.08	0.04	($0.63)
2	2.08	0.04	($0.63)
3	2.08	0.04	($0.63)
4	2.08	0.04	($0.63)
5	2.08	0.04	($0.63)
6	2.28	0.02	($0.91)
7	2.28	0.02	($0.91)
8	1.61	0.02	($0.20)
9	1.61	0.02	($0.20)
10	1.61	0.02	($0.20)
11	1.39	0.01	$0.36
12	1.39	0.01	$0.36
13	1.39	0.01	$0.36
14	1.39	0.01	$0.36
15	2.08	0.04	($0.63)
16	2.08	0.04	($0.63)

Level 2 – 25% Savings over 2005 Title 24

To estimate the Level 2 (25%) energy savings potential, we used the measures and technologies proposed for the 2013 Title 24 (Part 6) building energy codes update. In order to meet the California Strategic Plans stated goals of zero net energy residential buildings by 2020 and nonresidential buildings by 2030, the CEC target is a 15% improvement over the existing code in each code cycle. The 2013 code update represents a 15% improvement over 2008 Title 24. Because utility new construction incentive programs are designed to ready the market for the next code cycle, using the 2013 code proposals to represent current (2010/2011) new construction program measures and opportunities is a logical approach. The 2013 code update savings and associated incremental costs are documented in Codes and Standards Enhancement CASE reports submitted to the CEC by the IOUs. Level 2 savings and costs were estimated based on the 2013 CASE reports applied to the same building types as the 2008 potential study for consistency. Level 2 measures include the following:

» Glazing update

» Cool roof

» Daylighting - side lighting and top lighting

» Indoor lighting including lower LPDs and lighting controls

» Package HVAC controls and economizers

» Built-up HVAC controls

» Refrigerated warehouse insulation and equipment controls (Refr. WHS)

» Supermarket refrigeration equipment efficiency requirements and controls

» Hotel guest room occupancy sensors for HVAC and lighting controls

The measures are mapped to the building types as shown in Table 24.

Table 24. Mapping of Measures to Building Type

Building Type	Glazing	Cool Roofs	Daylighting	Indoor Lighting	Package HVAC	Built-Up HVAC	Refrig. WHS	Super-markets	Hotel Guest Room Occ. Sensors
College	X	X	X	X	X	X			
Grocery		X	X	X	X	X	X	X	
Hospital	X	X			X				
Hotel	X	X	X	X	X				X
Large Office	X	X	X	X	X	X			
Ref. Warehouse		X	X	X	X		X		
Restaurant	X	X	X	X	X	X			
Retail	X	X	X	X	X	X			
School	X	X	X	X	X	X			
Small Office	X	X	X	X	X	X			
Warehouse		X	X	X	X	X			
Misc.	X		X	X	X	X			

The Level 2 measures result in per square foot savings and associated costs as shown in Table 21.

Table 25. Level 2 (25%) Average Statewide Savings

	Savings per Sq Ft			
Climate Zone	Electric Savings (kWh)	Peak Electric Savings (kW)	Gas Savings (Therms)	Incremental Cost per Sq Ft
1	2.80	0.27	0.07	$ 0.36
2	2.52	0.03	0.05	$ 0.36
3	2.54	0.01	0.04	$ 0.36
4	2.48	0.01	0.05	$ 0.36
5	2.27	0.05	0.05	$ 0.36
6	2.55	0.01	0.04	$ 0.36
7	2.64	0.00	0.03	$ 0.36
8	2.53	0.01	0.03	$ 0.36
9	2.33	0.00	0.03	$ 0.36
10	2.50	0.01	0.03	$ 0.36
11	2.53	0.02	0.03	$ 0.36
12	2.39	0.00	0.02	$ 0.36
13	2.48	0.01	0.02	$ 0.36
14	2.39	0.04	0.02	$ 0.36
15	2.43	0.09	0.04	$ 0.36
16	3.07	0.04	0.07	$ 0.36

4.6.2.3 *Rollup savings to IOU territory*

We converted the savings expressed as savings per square foot (unit energy savings) by building type by climate zone to unit energy savings building type per home by utility territory for the EERAM model using the following methodology.

The CEC climate zones were first mapped to CEC forecast zones using information available from the California Energy Commission forecast staff. The forecast climate zones were then mapped to utility territories using a forecast zone to zip code mapping. Thus, each CEC climate zone was mapped to one or more utilities based on the number of zip codes served by each utility. Since this study is limited to the IOU programs, the areas/zip codes not served by IOU were excluded from the mapping exercise and thus the total of savings for all IOU combined is less than the total for all climate zones in the tables above.

4.7 *Approach to Codes and Standards*

We assessed energy savings potentials for three types of codes and standards (C&S) in this study.

- Federal appliance standards
- Title 20 appliance standards
- Title 24 building energy efficiency code

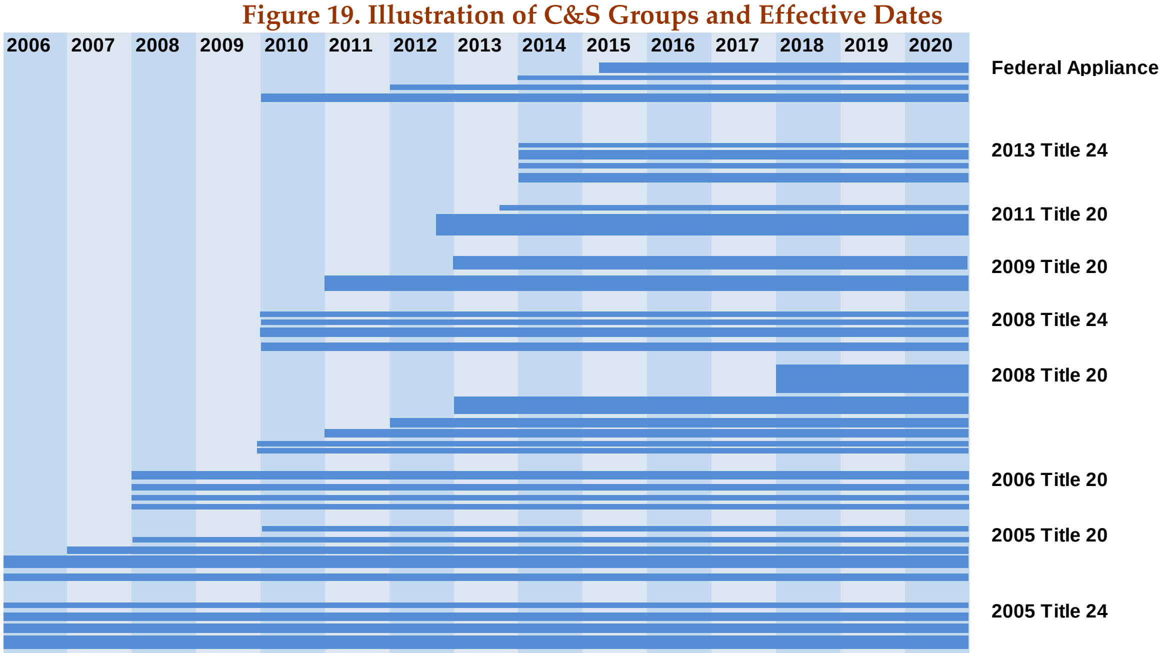
This section describes the approach to developing the Track 1 C&S Potential Model (based in Excel), including the scope, data sources, and calculation methodology.

4.7.1 Scope of IOU C&S Programs

Starting from the 2006-2008 program cycle, the CPUC began to treat IOU C&S programs as a resource program and count C&S program energy savings towards meeting IOU minimum performance standards (MPS). Therefore, future C&S program potentials are based on building codes and appliance standards that were covered by the 2006-2008 program cycle and those that were adopted or will be adopted in the future.

Figure 19 illustrates the state and federal standard groups that were considered in this study. Each horizontal bar represents an appliance standard or building energy code measure. The starting point of a bar indicates the effective date and the thickness illustrates the relative magnitude of the statewide energy impact of each measure. All of these (with the exception of 2013 Title 24 standards) have been previously adopted. The CEC has released the 2013 Title draft language, with the proposed adoption date, and has provided the estimated statewide energy impact. This is significant, because 2013 Title 24 requirements will take effect on January 1, 2014, and will directly impact new construction programs starting in 2014, which is one of the bridge program years. Therefore, projected 2013 Title 24 measures are included in this study.

Figure 19. Illustration of C&S Groups and Effective Dates



The following data sources were used to develop the list of appliance standards and building codes covered in the IOU C&S programs.

» ***2010-2012 C&S Program Evaluation Plan.*** In May 2011, the IOU statewide C&S team submitted C&S program energy savings estimates to the CPUC to support the 2010-2012 C&S program evaluation. The submission included Excel files that included detailed program data, assumptions, and energy savings calculation steps. The CPUC used the PG&E version of C&S program savings workbook (referred to as the "PG&E model") to develop the 2010-2012 C&S program evaluation plan. Data presented in this workbook are based on best available information and/or professional judgment and have not been verified by the CPUC. However, the PG&E model represents the best available data for IOU C&S programs. It has been reviewed by the CPUC ED without major objections raised. Therefore, it was used for this C&S program potential assessment.

- ***IOU Response to Additional Data Request.*** In response to a data request by the CPUC for the 2011 Goals and Targets Study, IOU C&S programs provided an updated C&S savings spreadsheet, referred as the "Updated PG&E Model" in the following discussion. The Updated PG&E Model provides additional information related to future Title 24 codes, future Title 20 standards, and future federal appliance standards.
- ***PG&E Comments to the Proposed 2013-2014 Goal[64].*** PG&E additional information regarding projected effective dates for selected future Title 20 and federal appliance standards according to updated CEC and DOE rulemaking schedules.

Based on the above data sources, IOU C&S program measures can be binned into four categories. A brief description of these four categories follows. Additional details, including the specific codes and standards included in each one, can be found in Appendix L.

- **Track 1 On-the-Books Codes and Standards:** On-the-books standards are those that have already been adopted into law.
- **Future Title 20 Standards:** IOU C&S programs have developed many Title 20 code change proposals. Several of those proposals are considered by the CEC to have higher priority than others. They are considered as the future Title 20 standards by this potential study.
- **Future Federal Appliance Standards:** The ***IOU Response to Additional Data Request*** provided a list of additional federal appliance standards that were not included in the PG&E model for supporting CPUC 2010-2012 evaluation. Among those standards, those that have been adopted or are projected to take effect in 2013 or 2014 are considered as Track 1 Future Federal Appliance Standards.
- **Future Title 24 Code:** The CEC is in the final rulemaking stage of adopting the 2013 Title 24, which is planned to take effect on January 1, 2014. The 2013 Title 24 is considered as the Track 1 Future Title 24 Code. Energy savings were estimated based on the results of CEC preliminary impact study. Energy savings from future local jurisdiction building reach codes were assumed to be the same as the estimated energy savings for 2012 reach code in the PG&E model.

We understand that there are also ongoing or planned state and federal standard development effects that will lead to future standards adoption. Based on general CEC and DOE rulemaking procedures, those new standards will most likely take effect after 2014, and therefore, won't affect the goal-setting for the 2013-2014 bridge period. In the second phase of this study, we will estimate the potential impact and energy savings from future C&S activities.

[64] Opening Comments of Pacific Gas and Electric Company (U 39-M) on Administrative Law Judge's Ruling Regarding 2013-14 Energy Efficiency Goals, Ann H. Kim and Mary A. Gandesbery, January 12, 2012.

4.7.2 C&S Modeling Methodology

Codes and standards affect IOU energy efficiency programs in two different ways. Codes and standards increase the amount of savings because they require customers to install high- efficiency measures in lieu of baseline equipment. The mandates can cause markets (a) to achieve higher levels of adoption and (b) to achieve those levels faster than possible in the absence of the legal mandate.

However, codes and standards also reduce the savings potential from traditional IOU rebate programs. C&S updates increase the baseline efficiency of utility-rebated measures, thus reducing the savings that IOUs can claim as a result of the rebate. The effects of state and federal standards to voluntary programs was quantified by the percentage impact to unit energy savings of affected voluntary program measures and are discussed in detail in Appendix L.

This potential study calculates the estimated savings of codes and standards on gross and net basis:

» **Gross C&S Savings** are the total energy savings estimated to be achieved from the updates to codes and standards since 2006. Gross savings are used in demand forecasting, procurement planning and for setting greenhouse gas targets.

» **Net C&S Program Savings** identify the portion of the total codes and standards savings that can be attributed to the advocacy work of the IOU's C&S program. Net savings calculations account for naturally occurring market adoption (NOMAD) of code compliant equipment and utility attribution factors. The potential study includes the net program savings in order to inform the IOU specific goals for portfolio planning.

The energy savings potentials of the IOU C&S advocacy program are determined by Annual Net C&S Program Savings and Cumulative Net C&S Program Savings, which are defined based on the C&S energy savings defined in the CPUC 2006-2008 C&S program evaluation report,[65] as shown in Figure 20.

» **Annual Net C&S Program Savings** are the energy savings attributed to IOU C&S programs from incremental installation of measures that comply with energy efficiency standards each year. They were calculated according to the definition of Net C&S Program Savings shown in Figure 20. This definition accounts for all C&S energy savings factors, including compliance rate, NOMAD, and utility attribution. Two types of measure installation are considered as incremental installation: 1) the new installation associated with new construction or first-time appliance purchase and 2) the first "replace-on-burnout" replacement after effective date of a corresponding standard.

» **Cumulative Net C&S Program Savings** are the energy savings attributed to IOU C&S programs from all incremental installations since 2006. These are attributable to the IOUs as a result of their advocacy work and technical support necessary to develop measures through a market adoption process that results in a measure being incorporated into code. They were calculated as the sum of Annual Net C&S Program Savings from 2006 to the year of interest.

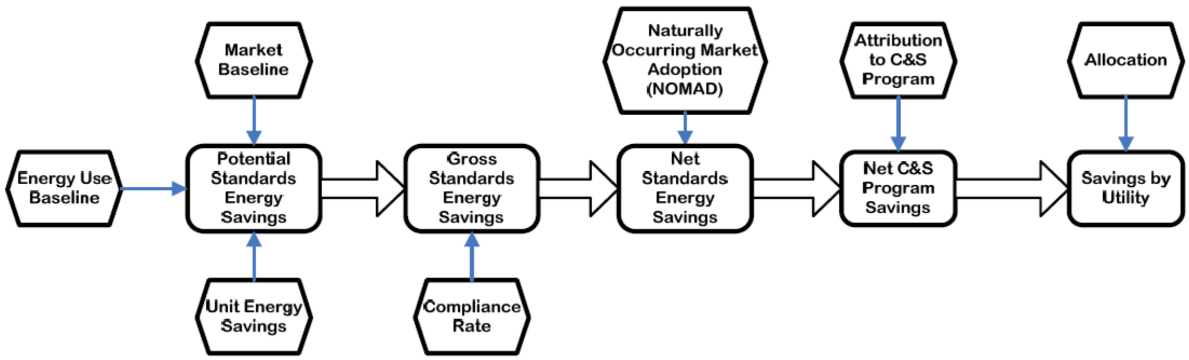
Detailed modeling of Annual Net C&S Program Savings and Cumulative Net C&S Program Savings were based on an Excel tool used by the CPUC to develop the 2010-2012 C&S program evaluation plan.

---

[65] Final Evaluation Report, Codes & Standards (C&S) Programs Impact Evaluation, California Investor Owned Utilities' Codes and Standards Program Evaluation for Program Years 2006-2008. Prepared by KEMA, Inc., The Cadmus Group, Inc., Itron, Inc., and Nexus Market Research, Inc. Utilities' Codes and Standards Program Evaluation for Program Years 2006-2008. Prepared by KEMA, Inc., The Cadmus Group, Inc., Itron, Inc., and Nexus Market Research, Inc.

Modifications of the tool were made according to the treatment of savings from replace on burnout measures defined in this study.

Figure 20. Definitions of C&S Program Gross and Net Savings



Source: CPUC 2006-08 C&S Program Evaluation Report.

The 2008 potential study[66] also analyzed the impact of C&S and presented the effects from an IOU perspective (reducing savings from voluntary programs) and from a societal perspective (increasing total savings due to the C&S). Limited by the available C&S development information at the time the study was developed, the 2008 potential study considered several scenarios of major C&S improvements. In contrast, the C&S analysis in this study is based on adopted standards or nearly adopted standards, so that the study better reflects actual C&S impacts instead of projected impacts. Table 26 compares how standards have been treated in the 2008 potential study and in this study.

[66] *California Energy Efficiency Potential Study*, ITRON, (2008) (www.calmac.org, CALMAC ID: PGE0264.01).

Table 26. Comparison of C&S Treatment in 2008 and 2011 Potential Studies

<table>
<tr><th rowspan="2">Standards Group</th><th colspan="2">2011 Study</th><th colspan="2">2008 Study</th></tr>
<tr><th>Impact to Voluntary Programs</th><th>C&S Program Savings</th><th>Impact to Voluntary Programs (IOU Perspective)</th><th>C&S Program Savings (Social Perspective)</th></tr>
<tr><td>Title 24</td><td colspan="2">2005, 2008, and 2013 Title 24; Compliance improvement scenarios included in C&S Program Savings</td><td>Assumed phase-out of new construction programs (15% above 2005 Title 24) by 2009; Residential new construction compliance improvement program starting from 2009</td><td>Assumed phase-out of new construction programs (15% above 2005 Title 24) by 2009 and scenarios of future Title 24 improvements</td></tr>
<tr><td>Title 20</td><td colspan="2">2005, 2006, 2008, 2009, and 2011 Title 20 (phase-in of Huffman Bill, which outlaws general service incandescent lamps)</td><td colspan="2">Assumed that Huffman Bill would improve general service lighting standards to phase-out CFL programs over 2011-2015</td></tr>
<tr><td>Federal Appliance Standards</td><td>All adopted federal standards</td><td>Federal standards reported by IOU C&S Programs</td><td>None</td><td>clothes dryers, dishwashers, residential central and room AC, commercial packaged terminal AC and heat pumps</td></tr>
</table>

4.7.3 C&S Program Energy Savings Calculation

Annual and Cumulative Net C&S Program Energy Savings

The Annual and Cumulative Net C&S Program Savings were using the following formula based on the definitions provide in the CPUC 2006-2008 C&S program evaluation report, as shown in Figure 20:

Annual Gross C&S Program Savings = UES * Annual Installation * Compliance Rate

Annual Net C&S Program Savings = Annual Gross Energy Savings * (1-NOMAD) * Attribution

Cumulative Net C&S Program Savings = $\sum_{\text{from 2006}}$Annual Net C&S Program Savings

Where the five C&S program energy savings factors are defined as follows:

- **UES** is unit energy savings of the new appliance standard or building code under consideration.
- **Annual Installation** (Market Baseline in Figure 20) is the annual appliance sales or construction activities affected by the new appliance standard or building code.
- **Measure Life** is the assumed effective useful life of the code-compliant equipment.
- **Compliance rate** is the percentage of annual installation (burnout replacement and new installation) that complies with the new appliance standard or building code.
- **NOMAD** represents Naturally Occurring Market Adoption and is the projected rate of market acceptance of the efficiency measure associated with the new standard, assuming that the standard was not adopted.
- **Attribution** to C&S Program is defined as the percentage of total standard development and advocacy efforts for a particular standard that can be attributed to the IOU C&S program.

The Energy Use Baseline included in Figure 20 is used to determine UES and, therefore, is not explicitly used in the above equations. Calculations of Annual Net C&S Program Savings and Cumulative Gross C&S Program Savings were performed for each standard and then added to provide total energy savings from each of the four standard categories.

A Track 1 C&S Potential Model was developed in Excel based on the "PG&E model" so that most of the assumptions used for supporting CPUC 2010-12 C&S program evaluation were also used for C&S program potential assessment. Assumptions of energy savings factors are summarized in Table 27. The following sections explain additional modeling issues and assumptions incorporated into Track 1 C&S Potential Model.

Table 27. Summary of Assumptions of C&S Energy Savings Factors

<table>
<tr><th>Standards Group</th><th>Unit Energy Savings</th><th>Annual Installation (Market Baseline)</th><th>Compliance Rate</th><th>NOMAD</th><th>Attribution</th></tr>
<tr><td>2005 Title 20</td><td colspan="5">2006-2008 Evaluation results</td></tr>
<tr><td>2006 Title 20</td><td colspan="2" rowspan="6">CASE Study Reports approved by CEC</td><td rowspan="6">Average 2005 Title 20 compliance rate weighted by savings (85%)</td><td rowspan="3">NOMAD curve of similar 2005 Title 20 standard</td><td rowspan="6">Average 2005 Title 20 attribution weighted by savings (74%)</td></tr>
<tr><td>2008 Title 20</td></tr>
<tr><td>2009 Title 20</td></tr>
<tr><td>2011 Title 20</td><td rowspan="3">Estimated based on CASE study information</td></tr>
<tr><td>Track 1 Future Title 20</td></tr>
<tr></tr>
<tr><td>All Federal Appliance Standards</td><td colspan="2">DOE rulemaking supporting documents</td><td>95%</td><td>NOMAD curve of similar 2005 Title 20 standard</td><td>6.25%</td></tr>
<tr><td>2005 Title 24</td><td colspan="5">2006-2008 Evaluation results</td></tr>
<tr><td>2008 Title 24</td><td colspan="2" rowspan="2">CASE Study Reports approved by CEC</td><td rowspan="2">Average 2005 Title 24 compliance rate weighted by savings (83%); 70% for alteration measures</td><td rowspan="2">Estimated based on CASE study information</td><td rowspan="2">Average 2005 Title 24 attribution weighted by savings (70%)</td></tr>
<tr><td>Track 1 Future (2013) Title 24</td></tr>
</table>

Realization Rate

A realization rate was applied to future codes and standards to more accurately reflect expected savings. The realization rate was based on evaluations of past codes and standards. Table 27 indicates that assumptions for pre-2006 codes are based on the CPUC 2006-08 C&S program evaluation report. Therefore, these assumptions are consistent with CPUC C&S evaluation methodologies. However, UES and annual installation for all post-2005 standards are based on documents approved by the CEC or

DOE. Through discussions with the CPUC and the IOUs, we determined that un-evaluated C&S savings may be overestimated.

Realization rates from the 2006-2008 evaluations were calculated and applied to un-evaluated C&S. Table 28 compares the Ex Ante Potential Standard Energy Savings of 2005 Title 24 and Title 20 standards based on CASE study reports and the corresponding Ex Post values based on the CPUC 2006-08 C&S program evaluation report. The ratio of corresponding values from the two sets of results is defined as the realization rate. Since CPUC-verified savings will be used to determine IOUs' achievement in meeting the goals, the realization rates in Table 28 were applied to corresponding un-evaluated standards. The realization rates of 2005 Title 24 were applied to post-2005 building codes and the realization rates for 2005 Title 20 were applied to post-2005 state and federal appliance standards.

Table 28. 2005 C&S Realization Rates

	Potential Standard Energy Savings GWh	Potential Standard Energy Savings MW	Potential Standard Energy Savings MMTherm
2005 Title 24			
Ex Ante – CASE Study Results	485	212	7.19
Ex Post – CPUC 2006-2008 Evaluation	293	86.8	4.16
Realization Rate	**61%**	**41%**	**58%**
2005 Title 20			
Ex Ante – CASE Study Results	612	92.8	2.47
Ex Post– CPUC 2006-08 Evaluation	716	124	6.59
Realization Rate	**85%**	**75%**	**37%**

It should be further noted that the market baseline forecast provided by the CPUC 2006-2008 evaluation report did not adequately reflect the significant impact to construction activities and, possibly, appliance sales, by the economic downturn faced by the state. For example, the single-family new construction predicted in the CPUC 2006-08 evaluation report is 111,148 units in 2011, while the actual new single-family home start in 2011 was only about 22,000 units.[67] There are no comprehensive market baseline predications that are based on the latest economic conditions and cover all relevant appliance sales and construction activities. Therefore, we recognize that there is a discrepancy between the market baseline assumptions provided by the CPUC 2006-2008 C&S program evaluation report and actual market conditions. This discrepancy is not covered by the realization rates listed in Table 28 and needs to be addressed in the CPUC Goal settings process.

Measure Life

[67] http://www.cbia.org/go/newsroom/press-releases/ite28099s-official-2011-marks-third-lowest-year-on-record-for-california-housing-production/; and http://firsttuesdayjournal.com/ca-single-and-multi-family-housing-starts/

In this study, the treatment of C&S program energy savings from burnout replacements was based on the same approach used in the EERAM model for voluntary programs. In the EERAM model, the technical potential associated with burnout replacements was defined as the energy savings from one-time replacement of available stock with the corresponding program measure. For the second or future burnout replacements, a fraction of voluntary program participants may still need incentives to sustain energy savings beyond one measure life (these customers are classified as "re-participants").

C&S programs operate on a different market mechanism in that all replacements, including both the first one and future ones, are required to use the energy efficiency technologies prescribed in the applicable standard. However, to be consistent with the definition of technical potentials for voluntary standards, annual gross and net C&S program energy savings from burnout replacements are limited to those from the first replacement after the corresponding standard effective date. Therefore, annual C&S program savings are corresponding to incremental installation of the corresponding efficiency technologies. Cumulative savings calculations for C&S do take into account future installations of equipment beyond the first installation of code-compliant equipment.

In the Track 1 C&S Potential Model, the annual installation is considered to include two components, burnout replacement and new installation. Based on the market data used in the EERAM model, it was assumed that 1% of the residential appliance sales and 2% of the commercial appliance sales were new installations. For building codes, it is assumed that all new constructions are new installations and alterations are burnout replacement. If compliance rate remains constant, only savings from new installations were counted towards annual gross and net C&S program savings after one measures life from the standard effective date. If compliance rate increases over time, energy savings associated with compliance rate improvement in burnout replacement are also included.

Compliance Rates and Compliance Enhancement

Post-2005 standards have not been evaluated and their compliance rate assumptions are based on compliance rates provided by CPUC 2006-2008 C&S program evaluation, as shown Table 27. Compliance rates of post-2005 appliance standards were based on the average compliance rate of 2005 Title 20 standards weighted by electricity savings. Federal appliance standards were assumed to have a compliance rate of 95%, higher than the average compliance rate of Title 20 standards. This is because federal standards provide uniform national requirements that are easier for manufacturers and distributors to meet. Compliance rates of post-2005 building codes that were based on the average compliance rate of 2005 Title 24 measures weighted by electricity savings. However, alteration measures were expected to have a lower compliance rate because many alteration projects might be started without a building permit. Therefore, for the following building measures, which were expected to generate significant savings from alterations, the compliance rates were assumed to be 70% (Ex Ante assumption for 2005 Title 24 measures).

- 2008 Title 24 Envelope Insulation
- 2008 Title 24 Tailored Indoor Lighting
- 2008 Title 24 Residential Swimming Pool
- 2008 Title 24 Cool Roof Expansion
- 2008 Title 24 Composite for Remainder
- 2013 Title 24 Others

The 2008 Itron potential study included an estimate of energy savings from compliance rate improvement for residential new construction buildings. The PG&E model includes the capability to assess energy savings from compliance improvement of individual standards. However, there are no studies available to support the development of compliance improvement assumptions. In addition, the compliance rates for 2005 Title 24 provided by the CPUC 2006-2008 C&S evaluation report were relatively high. It is uncertain if post-2005 standards will be able to achieve the same level of compliance, given the code requirements are more stringent. Therefore, no additional compliance improvements were assumed.

Interactive Effects

Standards that reduce electricity uses of appliances that are located within building envelope may increment building natural gas usages in heating seasons. The PG&E model considered this effect and provided interactive effect coefficients for affected standards. These interactive effects assumptions were included in assessing natural gas savings potentials. To clearly indicate the energy savings potentials to be achieved by natural gas efficiency measures, we provide two sets of results: with and without interactive effects. See Appendix L for details.

4.7.4 Results of C&S Program Energy Savings Potentials

Appendix L presents annual gross and net C&S program savings for each IOU from different standards groups. As an overview, Figure 21 presents the statewide annual gross and net C&S program savings from 2006 to 2024 from all IOUs and Table 29 presents detailed gross and net savings for each IOU. Net savings (as described before) including compliance rate, naturally occurring market adoption (NOMAD), and utility attribution. Net savings is the portion of C&S savings that can be directly attributed to IOU C&S advocacy programs. Gross savings, on the other hand, represent the total estimated savings resulting from C&S. Gross savings account for compliance rate but do not include NOMAD or utility attribution adjustments.

Incremental annual gross C&S program savings increase dramatically between 2009 and 2016, but decrease quickly after 2017. The increase is due to active standard adoption of new state and federal standards. Key contributors to quick ramp-up of annual gross C&S program savings include the following:

» 2008 Title 24

» 2008 Title 20 Incandescent lamp standards

» 2009 Title 20 TV standards

» 2011 Title 20 Battery Charger standards

» Federal Appliance standards (Most savings are from reflector and fluorescent lamp standards.)

All appliance standards in the above list have relatively short measure life. High annual savings only last for several years and, therefore, incremental annual gross C&S program savings drop off quickly after 2017.

While trends in the gross C&S savings are interesting to observe, incremental net C&S savings are used to inform IOU goals. The annual net C&S savings follows a similar rise and fall trend. However, net savings includes effects of NOMAD and IOU attribution factors, both of which can significantly reduce

IOU claimable savings. For example, gross savings for federal standards are significant though only about 6% of federal standard savings can be attributed to IOU programs.

Figure 21. Incremental Annual Gross and Net C&S Program Savings for all IOUs (GWh)

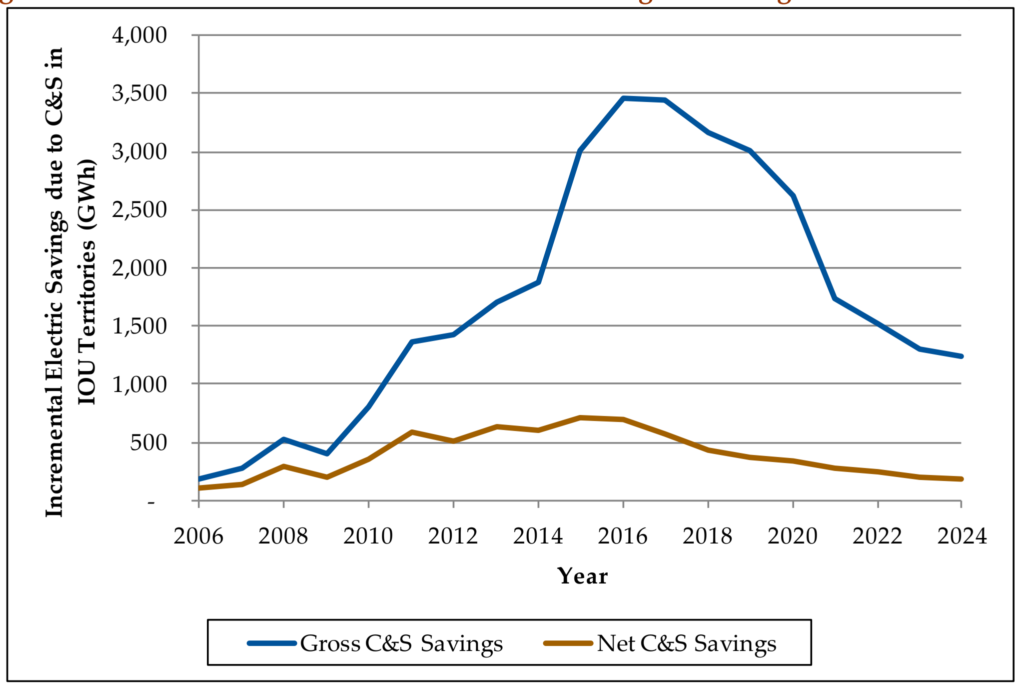


Table 29. C&S Net and Gross Savings Results

Annual Savings	IOU	2013	2014	2015	2016	2017	2018	2019	…	2024
Gross Electric Savings (GWh/yr)	PG&E	751	825	1,331	1,525	1,518	1,399	1,326	…	549
	SCE	774	851	1,373	1,573	1,566	1,443	1,367	…	566
	SDG&E	176	193	312	357	355	327	310	…	128
	Total	**1,701**	**1,869**	**3,016**	**3,455**	**3,439**	**3,169**	**3,004**	**…**	**1,243**
Net Electric Savings (GWh/yr)	PG&E	276	262	315	309	253	189	163	…	78
	SCE	285	270	325	319	261	195	168	…	81
	SDG&E	65	61	74	72	59	44	38	…	18
	Total	**626**	**593**	**714**	**700**	**573**	**428**	**370**	**…**	**177**
Gross Peak Savings (MW/yr)	PG&E	104	128	288	308	301	287	278	…	180
	SCE	107	132	297	318	310	296	286	…	186
	SDG&E	24	30	67	72	70	67	65	…	42
	Total	**235**	**290**	**653**	**698**	**681**	**651**	**629**	**…**	**408**
Net Peak Savings (MW/yr)	PG&E	36	38	54	52	45	37	33	…	22
	SCE	37	40	56	53	46	38	34	…	23
	SDG&E	8	9	13	12	11	9	8	…	5
	Total	**82**	**87**	**122**	**117**	**102**	**83**	**75**	**…**	**50**
Gross Gas Savings (MMMT/yr)	PG&E	1.3	2.1	0.6	-1.1	-1.0	-0.3	0.5	…	5.0
	SCG	2.1	3.3	0.9	-1.7	-1.6	-0.5	0.8	…	8.1
	SDG&E	0.1	0.2	0.1	-0.1	-0.1	0.0	0.1	…	0.6
	Total	**3.5**	**5.6**	**1.5**	**-2.9**	**-2.7**	**-0.8**	**1.4**	**…**	**13.7**
Net Gas Savings (MMMT/yr)	PG&E	1.1	1.6	1.7	1.5	1.8	2.1	2.3	…	2.2
	SCG	1.8	2.5	2.7	2.4	2.9	3.4	3.7	…	3.6
	SDG&E	0.1	0.2	0.2	0.2	0.2	0.2	0.3	…	0.3
	Total	**3.1**	**4.3**	**4.6**	**4.0**	**4.8**	**5.7**	**6.3**	**…**	**6.1**

4.8 Inclusion of Program Administrative Costs

The 2008 potential study did not include estimates of administrative costs within TRC calculations. Although administrative costs can vary by program design, they were added for this study because they are generally included in the typical TRC calculation. The approach is to estimate an average administrative cost per unit energy savings ($/kWh or $/therm) and multiply this value by the unit energy savings per measure to estimate the total administrative costs per measure.

Table 30 lists the starting administrative costs used in the study. The values are generic estimates based on utility program data. The model assumes that administrative costs for emerging technology programs will be 25% higher than the values in Table 30 because of the initial difficulty in promoting these technologies. The model also assumes that administrative costs drop over time as program awareness and willingness to participate improve. By 2024, it is expected that administrave costs will drop by 20%. The administrative costs do not start declining until 2013.

Table 30. Starting Administrative Costs for Utility Programs

Utility	Electric ($/kWh)	Gas ($/therm)
PG&E	$0.0070	$0.2350
SCE	$0.0085	NA
SCG	NA	$0.08925
SDG&E	$0.0085	$0.08925

4.9 *Accounting for Changes in Measure Costs Over Time*

EERAM allows measure technology costs to change over time as needed. Based on a DOE paper,[68] technology costs come down over time at a rate that varies by technology. The measures are mapped to a code that best matches the curves of technology cost reduction as identified in the DOE paper. This code matches the appropriate learning curve to the technology, with several technologies coded as having no change. Another variable in the model estimates where the technology is on the learning curve in terms of maturity (years). Table 31 lists the technologies, years, and associated cost learning rates.

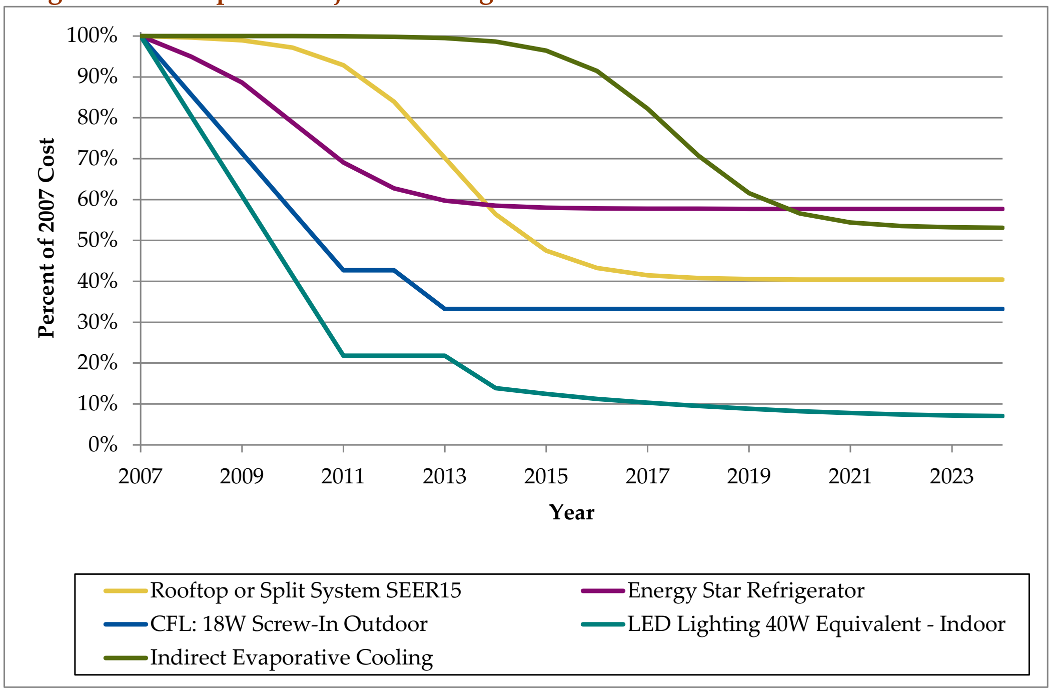
Table 31. Learning Rates by Technology

Code	Technology	Years	Learning Rate
2	Refrigerators	33	0.52
3	Freezers	20	0.38
4	Room AC	19	0.40
5	Unitary AC	30	0.18
6	Gas Water Heaters	35	0.13
7	Elec. Water Heaters	52	0.17
8	CFLs	8	0.53
10	Generic ET	8	0.53

Some measures, such as CFLs, do not use this learning curve approach, but rather estimate costs based on a life cycle that includes replacement incandescent lamps. The effects of codes impact these CFL costs. Figure 22 illustrates some of the technology cost reductions over time.

[68] U.S. Department of Energy (2011). Using the Experience Curve Approach for Appliance Price Forecasting. Supplemental draft paper to the DOE proposed rule in Docket No. EE-2008-BT-STD-0012.

Figure 22. Example of Projected Changes in Incremental Measure Costs Over Time



5 California Energy Efficiency Potential

5.1 Overview

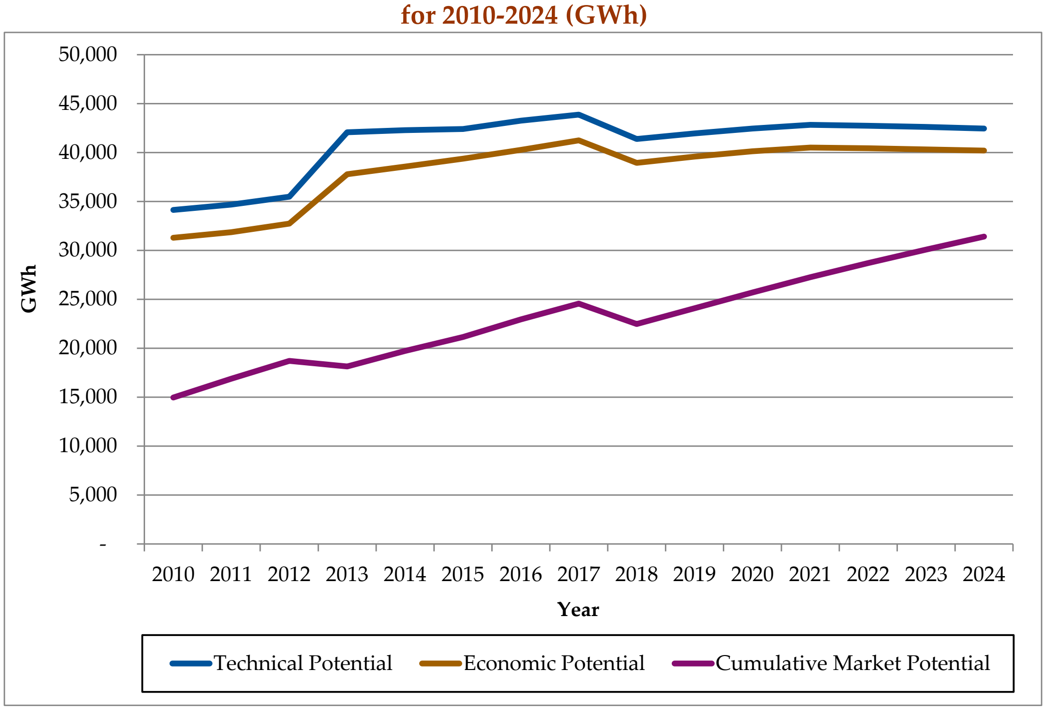
This section provides energy and demand savings potential estimates at the California statewide level. These are estimates of total technical, economic, and gross market potential for all sectors (residential, commercial, industrial, and agricultural) and all IOUs (PG&E, SCE, SDGE, and SCG). Sections 6, 7, 8, and 9 detail the technical and economic potential results by sector and discuss observed trends. Sections 10 through 13 discuss utility-specific results.

5.2 California Statewide Summary of Results

5.2.1 California IOU Electric Energy Potential

The technical, economic, and cumulative market energy savings potential in California are presented in Figure 23. The available technical potential is approximately 35,000 GWh in 2010, increasing to approximately 42,500 GWh in 2024. The economic potential follows a similar trend to technical potential beginning around 32,000 GWh in 2010 and increasing to just over 40,000 GWh in 2024[69]. These estimated include the contribution of IOU attributed codes and standards. The cumulative market potential is calculated to begin around 15,000 GWh 2010 and follows its own increasing trend to around 31,000 GWh in 2024.

Figure 23. California Gross Technical, Economic, and Cumulative Market Energy Savings Potential for 2010-2024 (GWh)



[69] The estimates in Figure 23 include the contribution of IOU attributed codes and standards. As discussed in Figure 2 when C&S is excluded the with technical and economic potential in 2024 is estimated at approximately 35,000 and 33,000 , respectively.

The increase in technical and economic potential in 2013 is due to the introduction of emerging technologies; the decreases occurring through 2018 are due to changes in codes and standards that result in higher baseline efficiency for affected measures as discussed in section 4.7. Cumulative market potential follows a steadier increasing trend, expecting a dip in 2018 as a result of codes and standards. This is attributed to market barriers with the introduction of emerging technologies in 2013; however, as time passes, the cumulative market potential increases at a faster rate than that of technical or economic potential as these technologies increasingly saturate the market. These trends are discussed in more detail in Sections 6 (Residential Sector Potential Results) and 7 (Commercial Sector Potential Results). Figure 24 displays similar results for California's technical and economic demand savings potential for the years 2010 through 2024.

Figure 24. California Gross Technical, Economic, and Cumulative Market Demand Savings Potential for 2010-2024 (MW)

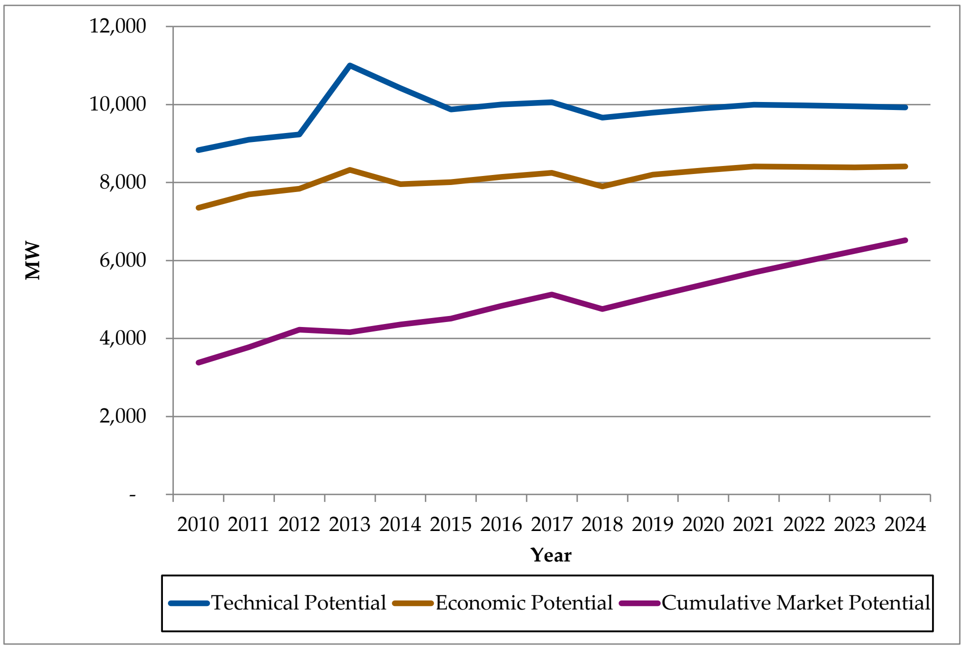


Table 32 provides a comparison of the technical and economic potential energy (GWh) for forecasts in the 2008 and 2011 reports for the period from 2010 through 2016. By the year 2016, forecasts for technical and economic potential in the 2011 potential study are approximately 38,490 GWh and 35,507 GWh, respectively, which vary slightly from the 2008 potential study estimates for that year. Table 33 provides a comparison of the change in coincident demand potential. Demand Potential over the forecast period is higher than 2008 potential study. It is likely that the increase in demand reflects that most GWh reductions result from reduced potential from CFL lighting that have a lower coincidence factor than many other measures in the portfolio. As such, changes in portfolio energy efficiency potential may not correlate well with changes in portfolio demand savings potential. CFL lighting is the source of the majority of GWh reductions during this timeframe. The increase in demand potential from the previous report results primarily from increased estimates in demand savings attributable to various HVAC measures.

Table 32. Changes in California Technical and Economic Energy Potential from the Previous Forecast (GWh)

Year	Technical			Economic		
	2008 Study	2011 Study	Percent Increase or Decrease	2008 Study	2011 Study	Percent Increase or Decrease
2010	36,354	33,081	-9%	31,799	30,231	-5%
2011	38,158	33,049	-13%	33,263	30,219	-9%
2012	39,894	33,349	-16%	34,660	30,597	-12%
2013	41,334	39,299	-5%	35,765	35,014	-2%
2014	42,704	38,935	-9%	36,808	35,211	-4%
2015	43,956	38,338	-13%	37,741	35,302	-6%
2016	44,880	38,490	-14%	38,347	35,507	-7%

Table 33. Changes in California Technical and Economic Demand Potential from the Previous Forecast (MW)

Year	Technical			Economic		
	2008 Study	2011 Study	Percent Increase or Decrease	2008 Study	2011 Study	Percent Increase or Decrease
2010	6,542	8,645	32%	5,214	7,165	37%
2011	6,999	8,830	26%	5,553	7,427	34%
2012	7,443	8,889	19%	5,881	7,494	27%
2013	7,845	10,572	35%	6,170	7,897	28%
2014	8,233	9,906	20%	6,449	7,444	15%
2015	8,603	9,236	7%	6,709	7,375	10%
2016	8,924	9,245	4%	6,924	7,392	7%

California's gross incremental market potential for energy savings is calculated to be 3,262 GWh in 2010 and approximately 1,472 GWh in 2024, as presented in Table 34, excluding codes and standards. Figure 25 shows incremental market potential by sector, including an estimate of the contribution for IOU attributed C&S.

Table 34. Gross Incremental Market Potential in California (GWh, excluding codes and standards)

Sector	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
California Statewide	3,262	2,158	1,884	1,422	1,427	1,464	1,480	1,482	1,493	1,484	1,500	1,523	1,535	1,508	1,472

Figure 25. California Gross Incremental Energy Savings Market Potential for 2010-2024 (GWh)

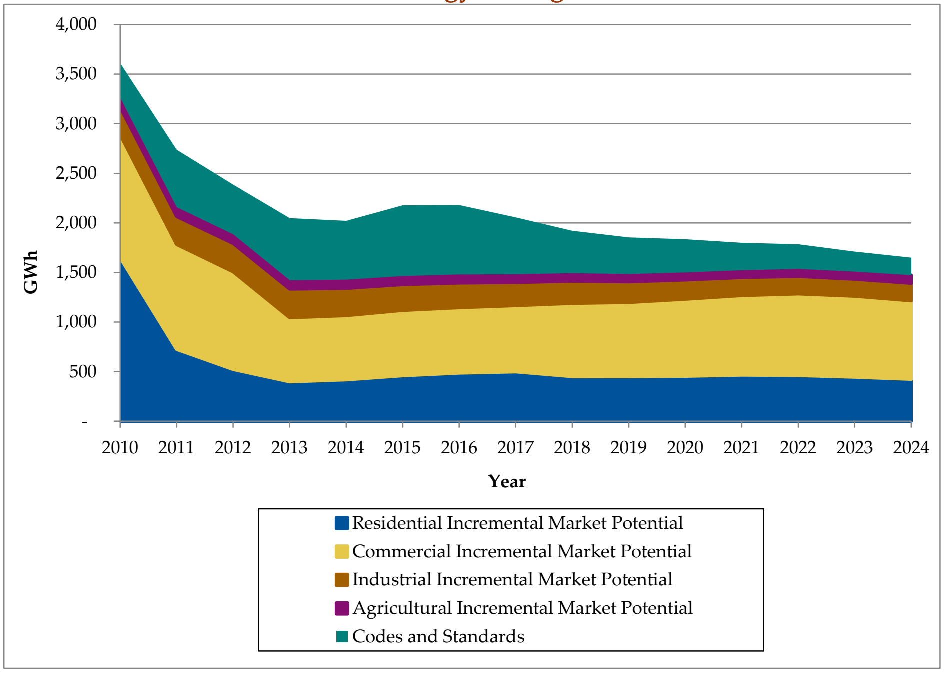


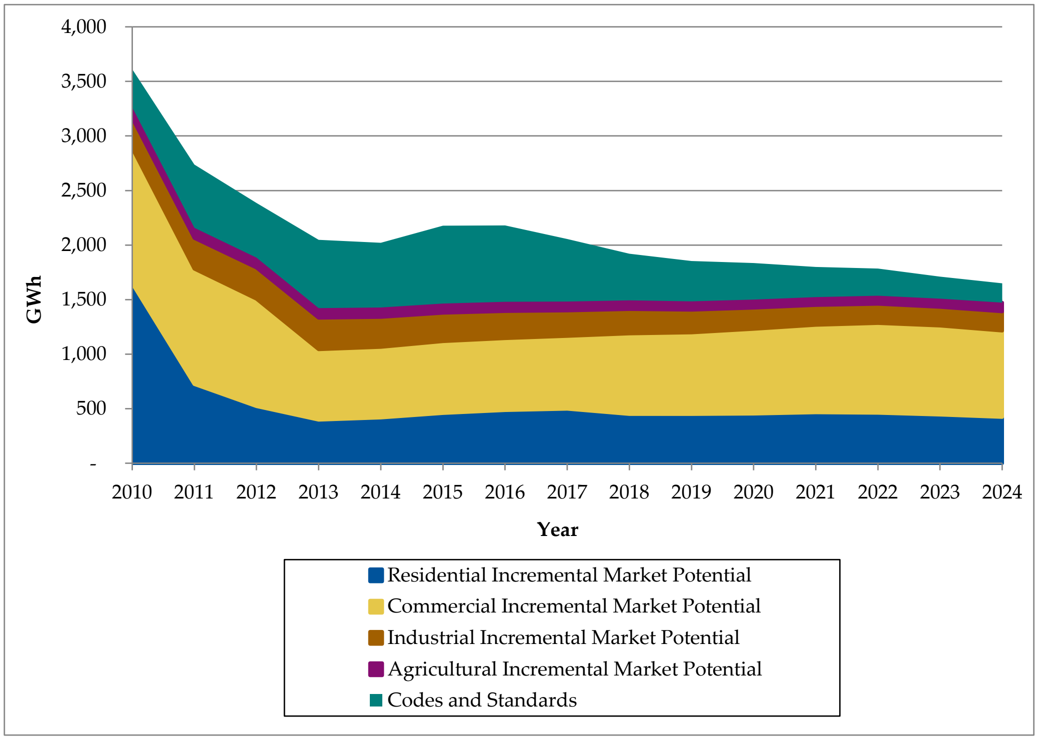
Table 35 presents incremental market potential by measure group. HIMs contribute the majority (56%) of total savings in 2010; by 2024 they contribute 14 % of the savings. This is due to HIM getting saturated in CA market and the emergence of new ETs and Codes & Standards.

Table 35. Incremental Programmatic Market Potential by Measure Group (GWh)

Year	HIM	Secondary	MOI	ET	Low Income	Usage Based Behavior	Codes and Standards
2010	2,058	683	440	0	81	0	350
2011	1,063	651	362	0	81	0	580
2012	818	631	354	0	81	0	501
2013	340	595	274	100	88	24	626
2014	304	562	290	136	88	48	593
2015	300	540	298	187	88	50	714
2016	286	519	287	252	85	51	700
2017	284	492	268	324	61	52	573
2018	255	459	360	331	34	54	428
2019	246	441	325	392	24	56	370
2020	242	432	304	448	17	58	335
2021	244	428	285	493	13	60	276
2022	239	431	270	523	10	62	249
2023	231	431	243	534	6	64	202
2024	228	442	212	523	2	66	177

Gross incremental market demand savings market potential (as seen in Figure 26) follows a similar trend as the energy savings potential; this decreases from approximately 800 MW in 2010 to just over 300 MW in 2024.

Figure 26. California Gross Incremental Demand Savings Market Potential for 2010-2024 (MW)



5.2.2 California IOU Natural Gas Potential

California's technical, economic, and cumulative market gas savings potential is presented in Figure 27. The available technical potential for natural gas savings is approximately 1,300 million therms in 2010, increasing to approximately 1,900 million therms in 2024. The economic potential is calculated to be 1,000 million therms in 2010 and 1,600 million therms in 2024. The cumulative market potential steadily increases from around 200 million therms in 2010 to 1,000 million therms in 2024.

Figure 27. California Gross Technical, Economic, and Cumulative Market Gas Energy Savings Potential for 2010-2024 (Million Therms)

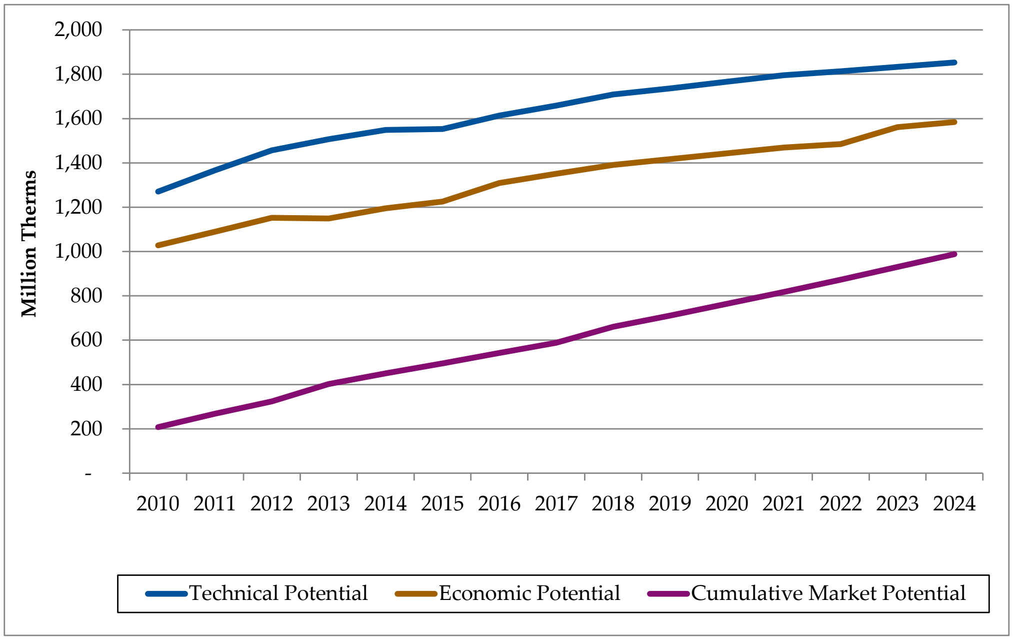


Figure 28 presents the gross incremental market potential for gas energy savings. The gross market potential is 35 million therms in 2010 increasing to just over 60 million therms again in 2024. Gas potential from the residential sector is negative in 2010 due to interactive effects with lighting efficiency equipment.

Figure 28. California Gross Incremental Energy Savings Market Potential for 2010-2024 (Million Therms)

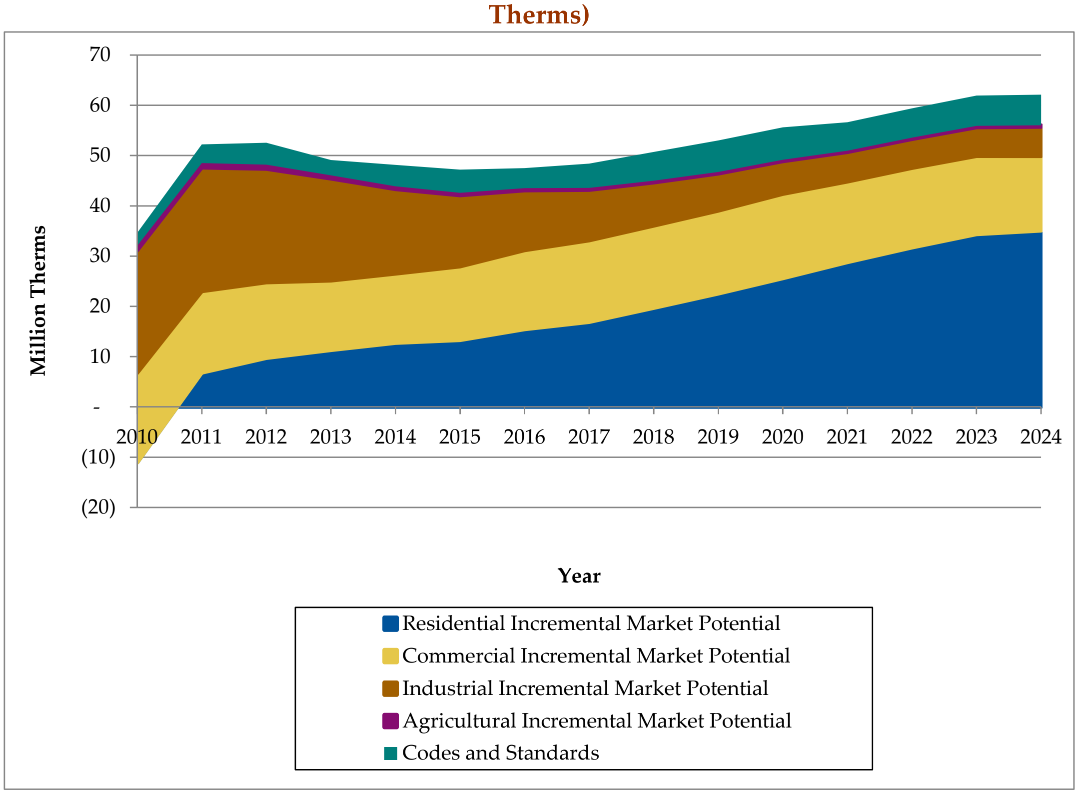
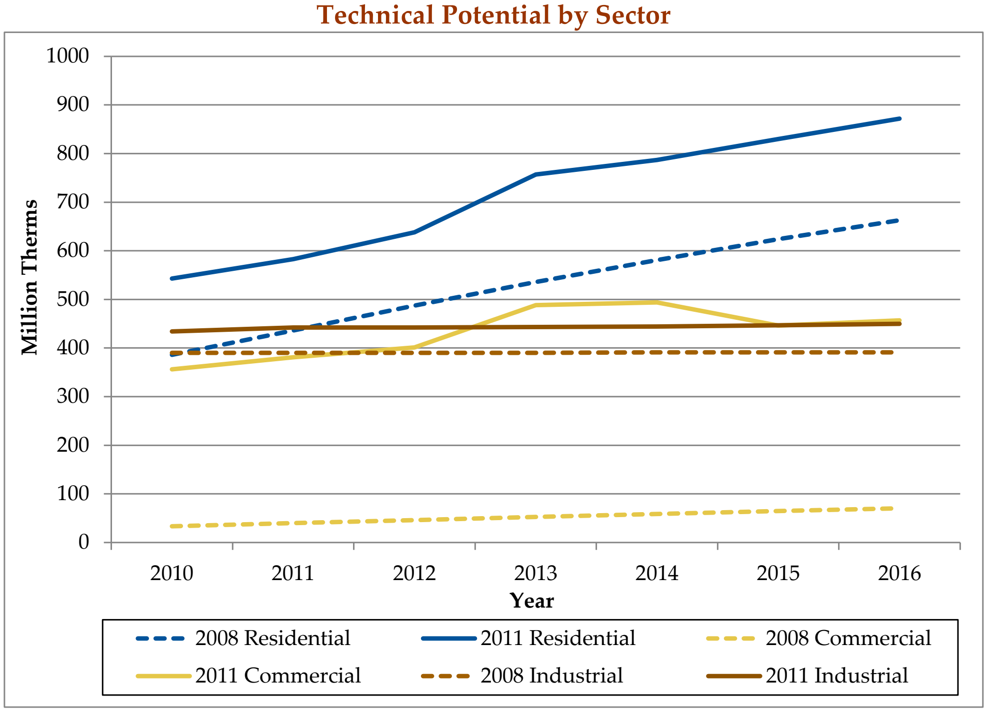


Table 36 provides a comparison of the technical and economic potential for gas energy savings forecasts in the 2008 and 2011 reports for the period from 2010 through 2016. Technical and economic potential are both increased by large percentages, but much of the difference is attributable to difference in the potential estimates for the commercial sector. As shown in Figure 29, the 2008 and 2011 studies are in general agreement about the amount of technical potential for the residential and industrial sectors; however, there is an order of magnitude difference in the commercial market estimates.

Table 36. Changes in California Technical and Economic Energy Potential from the Previous Forecast (Millions of Therms)

Year	Technical			Economic		
	2008 Study	2011 Study	Percent Increase or Decrease	2008 Study	2011 Study	Percent Increase or Decrease
2010	869	1,225	41%	539	986	83%
2011	942	1,317	40%	559	1,043	87%
2012	1,015	1,404	38%	580	1,101	90%
2013	1,086	1,459	34%	597	1,103	85%
2014	1,155	1,499	30%	616	1,145	86%
2015	1,220	1,499	23%	638	1,172	84%
2016	1,282	1,556	21%	656	1,251	91%

Figure 29. Comparison of 2008 Potential Study and 2011 Potential Study Gas Energy Savings Technical Potential by Sector



6 Energy Efficiency Potential in California's Residential Sector

This section provides the estimates of potential energy and demand savings at the statewide level for Residential buildings, including Single-Family and Mobile Homes (SF), Multi-Family structures (MF), and Residential New Construction (RNC).

6.1 Overview

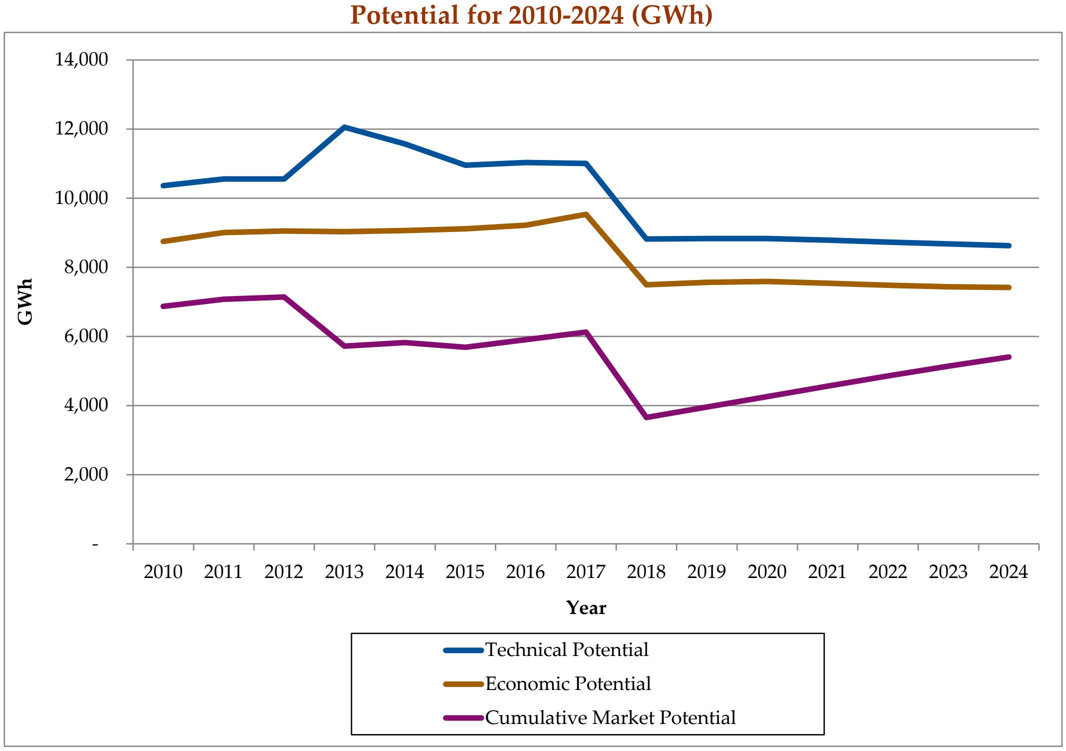
Codes and standards changes for residential lighting and the introduction of new plug load measures into the utility portfolio (e.g., ENERGY STAR Set Top Boxes) significantly impact the residential energy and demand savings potential. The technical, economic, and cumulative market potentials decrease over time due to the inclusion of codes and standards in the analysis.

6.2 California Residential Summary of Results

6.2.1 California Residential Electric Energy Potential

The technical energy savings potential in the residential sector decreases from approximately 11,500 GWh in 2010 to 8,500 GWh in 2024. The economic potential stays at approximately 80% of the technical potential, starting at 8,900 GWh in 2010 and decreasing to 7,500 GWh in 2024. Cumulative market potential follows a similar trend to economic potential beginning at 7,000 GWh in 2010 and falling to 5,500 GWh in 2024. These trends are presented in Figure 30.

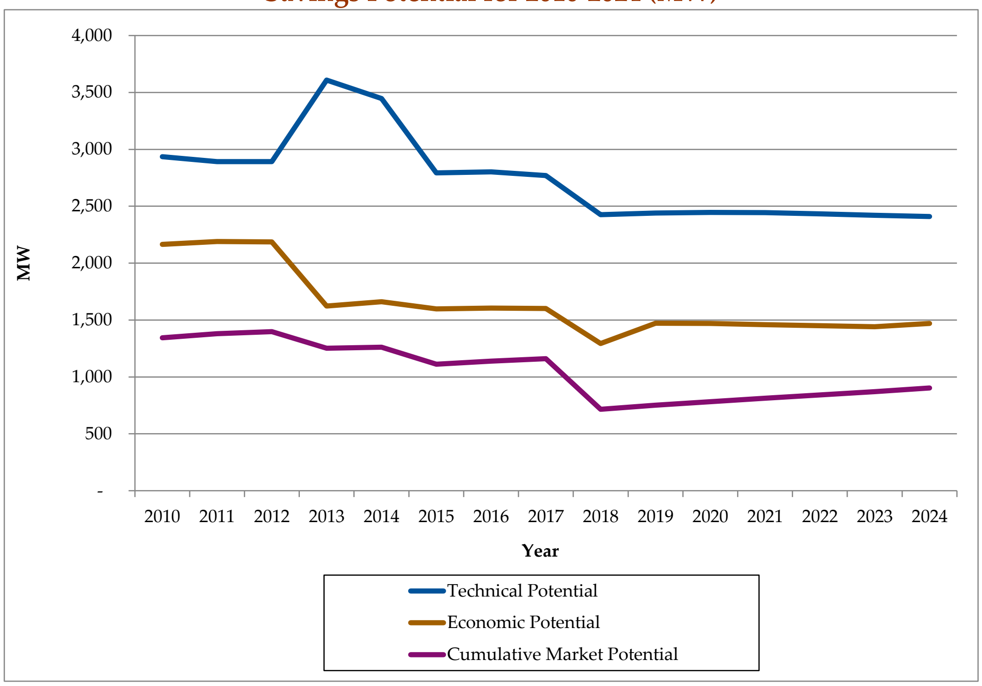
Figure 30. California Residential Gross Technical, Economic, and Cumulative Market Energy Savings Potential for 2010-2024 (GWh)



The overall decrease in technical, economic, and cumulative market potential is due to the increase in savings attributable to codes and standards. The sharp decreases in potential in 2013 and 2018 are due to changes in residential lighting codes and standards. Further explanation of this phenomenon is presented in Section 4.2.

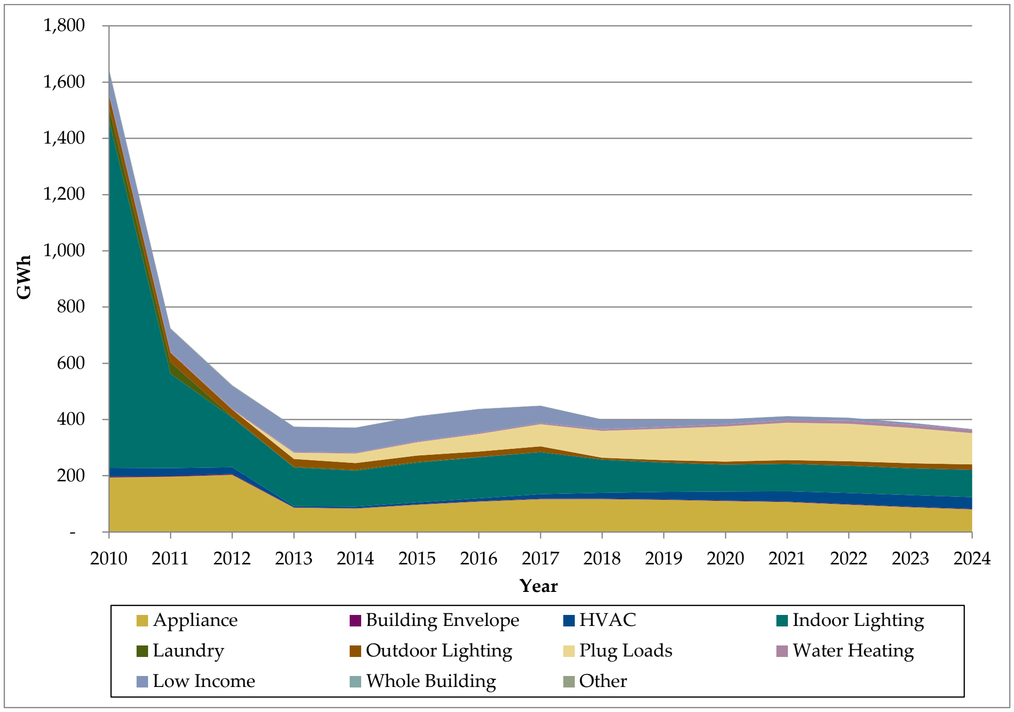
Figure 31 presents the gross technical, economic, and cumulative market demand savings potential for California's residential sector from 2010 through 2024. The economic potential curve for demand savings follows a similar trend to the economic and technical energy savings potential curves: there is a sharp decrease in potential savings in 2013 and in 2018. The technical potential for demand savings, in contrast, increases sharply in 2013 due to the introduction of emerging technologies to utility portfolios and due to HVAC measures. HVAC measures have a high demand to energy savings ratio as compared to other residential measures; they drive the technical demand savings potential. These HVAC measures do not contribute significantly to the economic potential as they do not pass the cost test (Total Resource Cost test) screen. Even though HVAC measures do not pass cost-effectiveness tests individually, they can be made cost effective when they are bundled together. The cumulative market potential follows a similar path to the cumulative market energy potential (shown earlier), starting at approximately 1,400 MW in 2010 and falling to 900 MW in 2024.

Figure 31. California Residential Gross Technical, Economic, and Cumulative Market Demand Savings Potential for 2010-2024 (MW)



California's residential sector incremental market potential decreases from approximately 1,600 GWh in 2010 to approximately 350 GWh in 2024, as presented in Figure 32. This figure breaks out the savings by DEER measure category and shows the extreme effect of codes and standards on indoor lighting prior to 2013.

Figure 32. California Residential Gross Incremental Market Potential for 2010-2024 (GWh)



In 2013, the incremental market potential is 3.1% of the available technical potential in that year; in 2024, the incremental market potential is approximately 4.2% of the available technical potential. This is because emerging technologies and secondary measures are responsible for the majority of the technical and economic potential in later years. As awareness of and willingness to implement these measures increases over time, an increasing percent of technical and economic potential savings can be captured by the market potential.

Figure 33 presents the gross incremental market potential for demand savings in California's residential sector from 2010 through 2024. The market potential decreases from 325 MW in 2010 to approximately 40 MW in 2024, similar to the market potential curve for energy savings.

Figure 33. California Residential Gross Incremental Demand Savings Market Potential for 2010-2024 (MW)

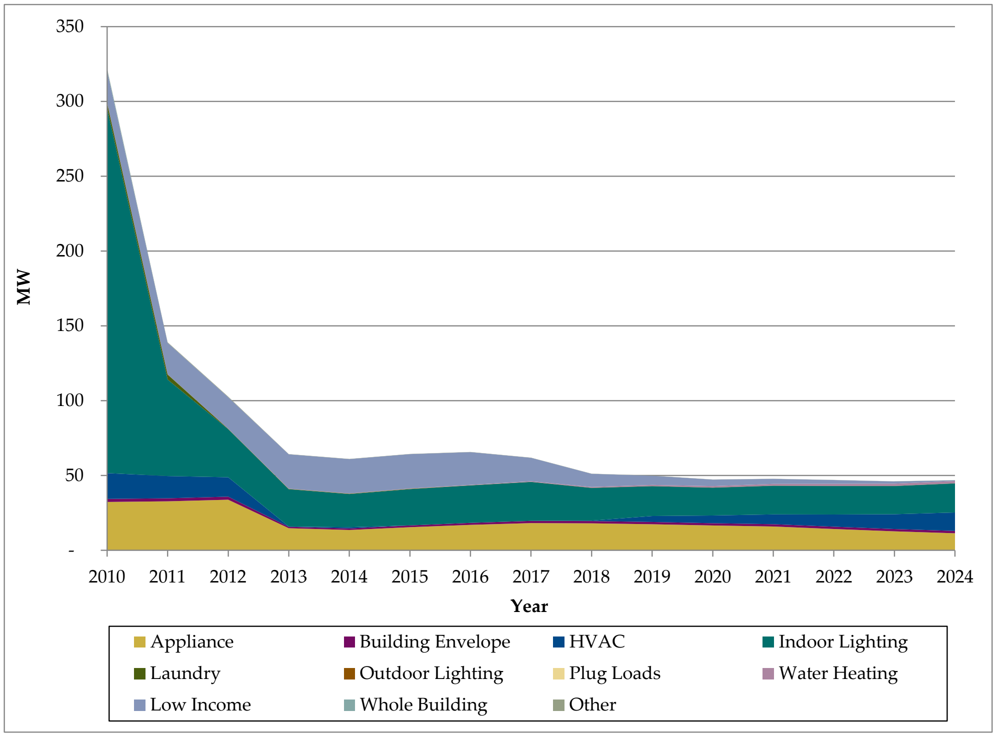


Figure 32 and Figure 33 break out the incremental market potential of residential energy and demand savings by DEER category. Lighting, HVAC, and Plug Loads have the largest energy savings potential. Since Plug Load measures are only recently being considered for inclusion in utility program portfolios, their impacts are not seen until after 2012. Lighting, HVAC, and Appliances have the largest demand savings potential, due to their peak hours of use. Although Lighting measures are the largest contributor to both energy and demand savings potential, changes in codes and standards decrease their savings contribution over time, most significantly at year 2013.

Comparison to 2008 Potential Study

Table 37 compares the economic and technical potential estimates of the 2008 potential study[70] and the 2011 potential study. The technical and economic potential estimates calculated by the 2011 potential study are significantly lower than those calculated by the 2008 potential study. Reasons for this difference include the following:

» The 2011 potential study used ex post energy savings estimates while the 2008 potential study used ex ante energy savings estimates.

» The 2011 potential study used extensive on-site residential lighting study results to calculate savings from residential lighting measures. These estimates were conservative as compared to 2008 potential study estimates (Table 13).

» The 2011 potential study analyzed the impact of codes and standards changes on technical and economic potential; the details of these codes and standard changes were not fully known and understood at the time the 2008 potential study was conducted.

[70] *California Energy Efficiency Potential Study*, ITRON, (2008) (www.calmac.org, CALMAC ID: PGE0264.01).

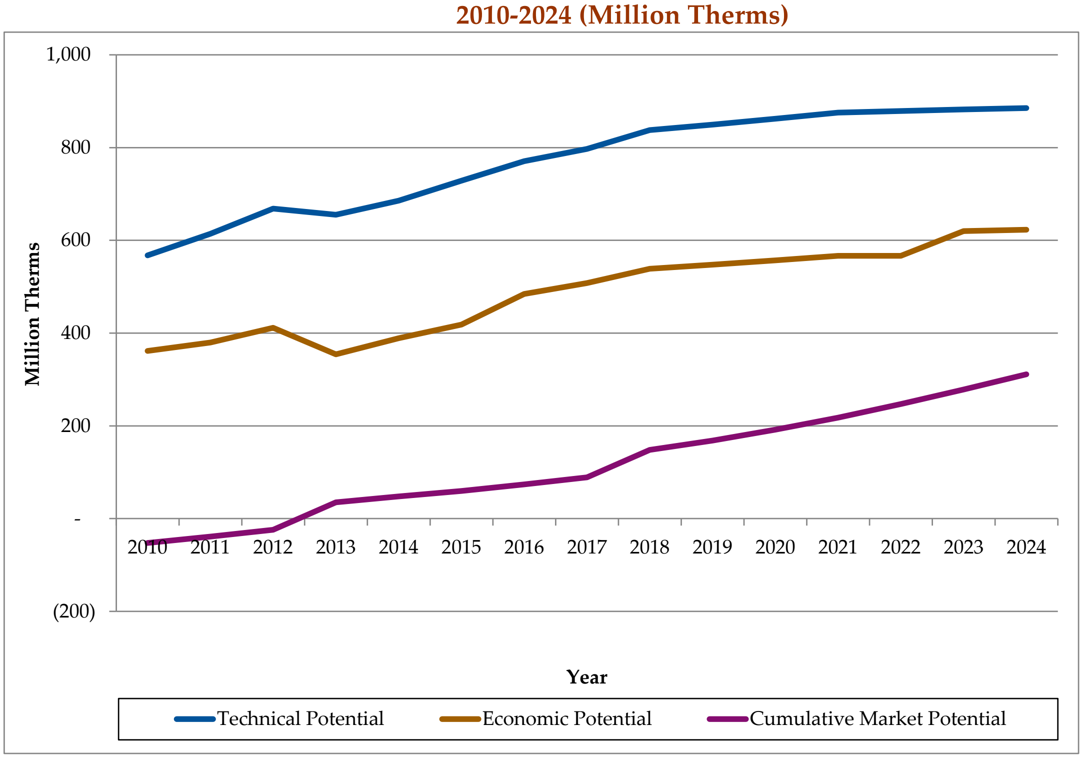
Table 37. Changes in California Residential Technical and Economic Energy Potential from the Previous Forecast (GWh)

Year	Technical			Economic		
	2008 Study	2011 Study	Percent Increase or Decrease	2008 Study	2011 Study	Percent Increase or Decrease
2010	17,011	10,359	-39%	14,458	8,749	-39%
2011	17,734	10,551	-41%	14,972	9,006	-40%
2012	18,442	10,554	-43%	15,476	9,048	-42%
2013	18,913	12,050	-36%	15,741	9,030	-43%
2014	19,339	11,571	-40%	15,965	9,060	-43%
2015	19,674	10,953	-44%	16,105	9,115	-43%
2016	19,823	11,027	-44%	16,061	9,216	-43%

6.2.2 California Residential Natural Gas Potential

California's residential technical potential for gas savings increases overall from 580 million therms in 2010 to approximately 900 million therms in 2024. The economic potential stays between 55% and 70% of technical potential for all years; it increases from 360 million therms in 2010 to 625 million therms in 2024. The cumulative market potential begins at -70 million therms in 2010 and increases to 315 million therms in 2024. Cumulative savings is negative due to interactive effects with efficient lighting equipment that has been installed in prior program years. Negative gas impacts due to efficient lights installed in SCE territory are included in this graph. This information is presented in Figure 34.

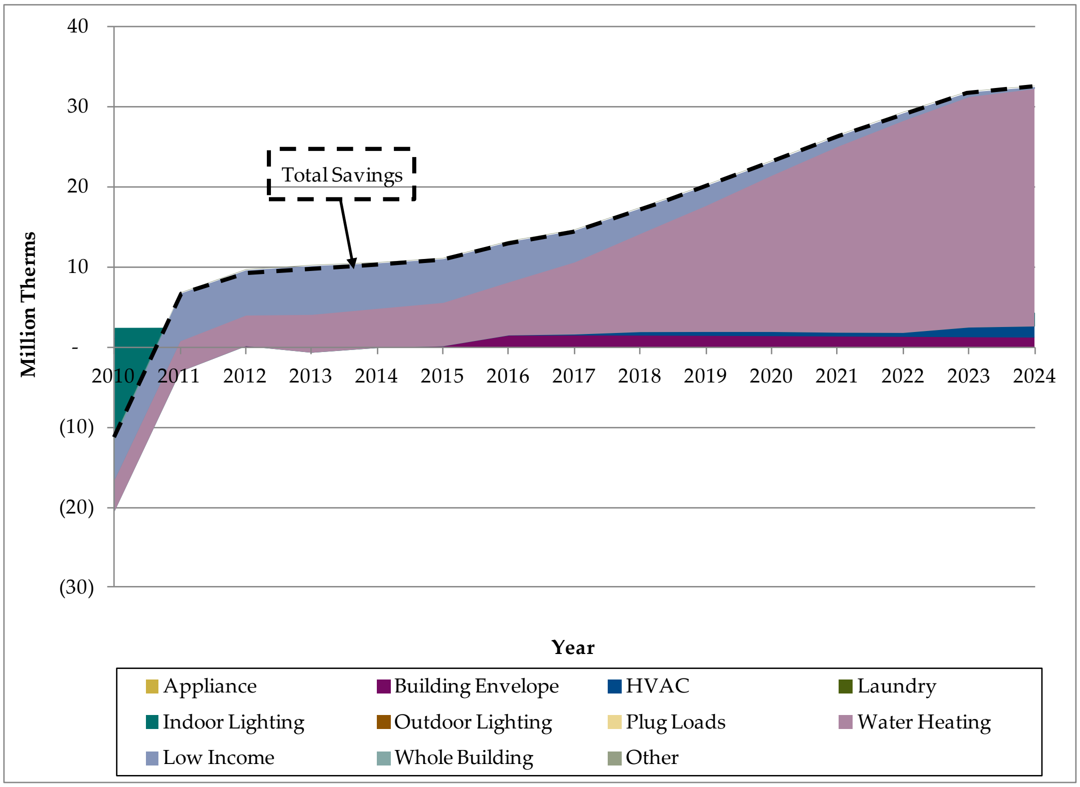
Figure 34. California Residential Gross Technical, Economic, and Cumulative Market Potential for 2010-2024 (Million Therms)



Unlike the technical, economic, and cumulative market potential for energy savings (Figure 30), these potentials for gas savings do not decrease over time as there are no significant codes and standards changes that impact gas measures. Cumulative market potential begins in the negative, but this is due to this study's inclusion of interactive effects between therms and energy.

Figure 35 presents the residential incremental market potential for gas savings measures in California. California's residential incremental market potential for gas savings increases over time starting at -10 million therms in 2010 up to 34 million therms in 2024. Savings are negative in 2010 due to interactive effects with efficiency lighting measures. This figure breaks out the potential terms savings by DEER category and shows that the main cause of the increase is water heating. This increase is due to the fact that very-high-efficiency water heating measures (including steam condensing boilers) become cost-effective starting in 2016.

Figure 35. California Residential Gross Incremental Market Potential for 2010-2024 (Million Therms)



7 Energy Efficiency Potential in California's Commercial Sector

This section summarizes the estimates of potential energy and demand savings at the statewide level for all commercial buildings, including existing buildings and Commercial New Construction (CNC).

7.1 *Overview*

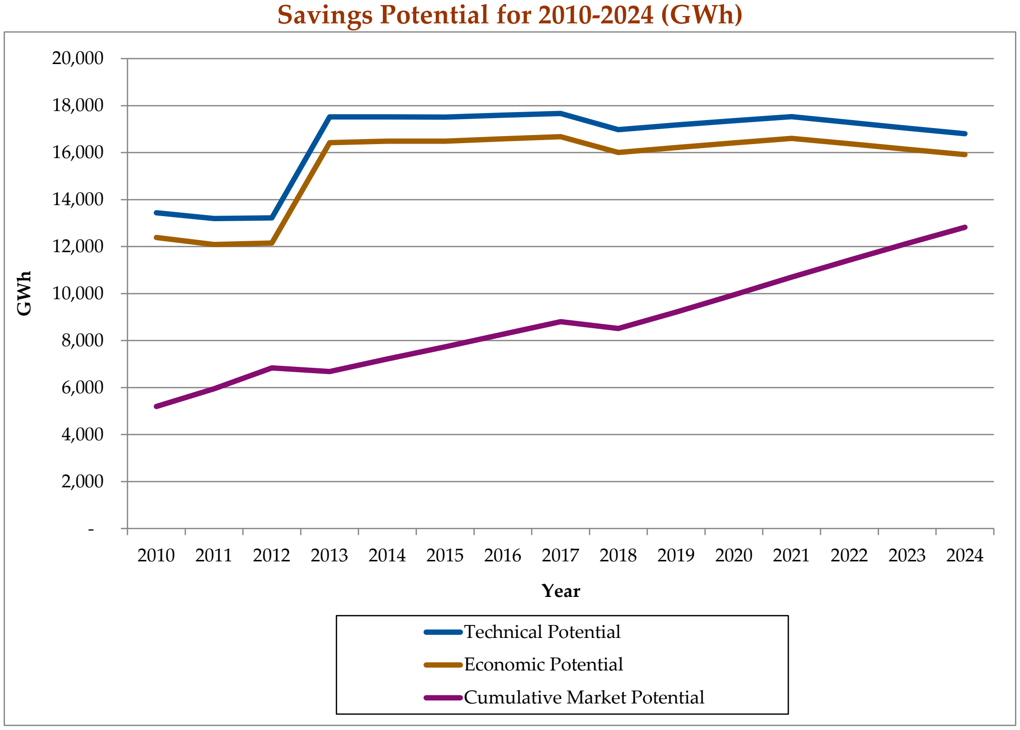
The potential energy savings in the commercial sector are impacted significantly by upcoming codes and standards changes (especially lighting and motors) and the introduction of emerging technologies to utility portfolios. These impacts are explained in detail below.

7.2 *California Commercial Summary of Results*

7.2.1 California Commercial Electric Energy Potential

The technical potential for energy savings in the commercial sector varies from approximately 13,500 GWh in 2010 to approximately 17,000 GWh in 2024. The economic potential stays at approximately 90% of the technical potential, increasing approximately from 12,000 GWh in 2010 to 16,000 GWh in 2024. The cumulative market potential increases on a separate trend line from approximately 5,000 GWh in 2010 to just below 13,000 GWh in 2024. Figure 36 presents the technical, economic, and cumulative market electric energy savings potential in California from 2010 through 2024.

Figure 36. California Commercial Gross Technical, Economic, and Cumulative Market Energy Savings Potential for 2010-2024 (GWh)



Technical and economic potential decrease starting in 2010 due to codes and standards changes, but the decrease is offset by the introduction of emerging technologies starting in 2013, shown by the spike in potential in 2013. Cumulative market potential steadily captures more and more of the emerging technologies energy potential as the market becomes more aware of and willing to implement these measures over the forecast years.

Figure 37 presents the technical, economic, and cumulative market demand savings potential in the commercial sector. The gross incremental market demand savings potential shows a similar trend as the energy potential curve: there is a sharp increase in technical and economic potential when emerging technologies are introduced in 2013 and a sharp decrease due to lighting codes and standards changes in 2014. The demand savings technical potential is calculated to be approximately 4,200 MW in 2010 and 4,700 MW in 2024; the economic potential stays at approximately 80% of the technical potential throughout this time period. The cumulative market potential follows a different trend, starting at 1,500 MW in 2010 and increasing to 3,500 MW in 2024.

Figure 37. California Commercial Gross Technical, Economic, and Cumulative Market Potential for Demand Savings in 2010-2024 (MW)

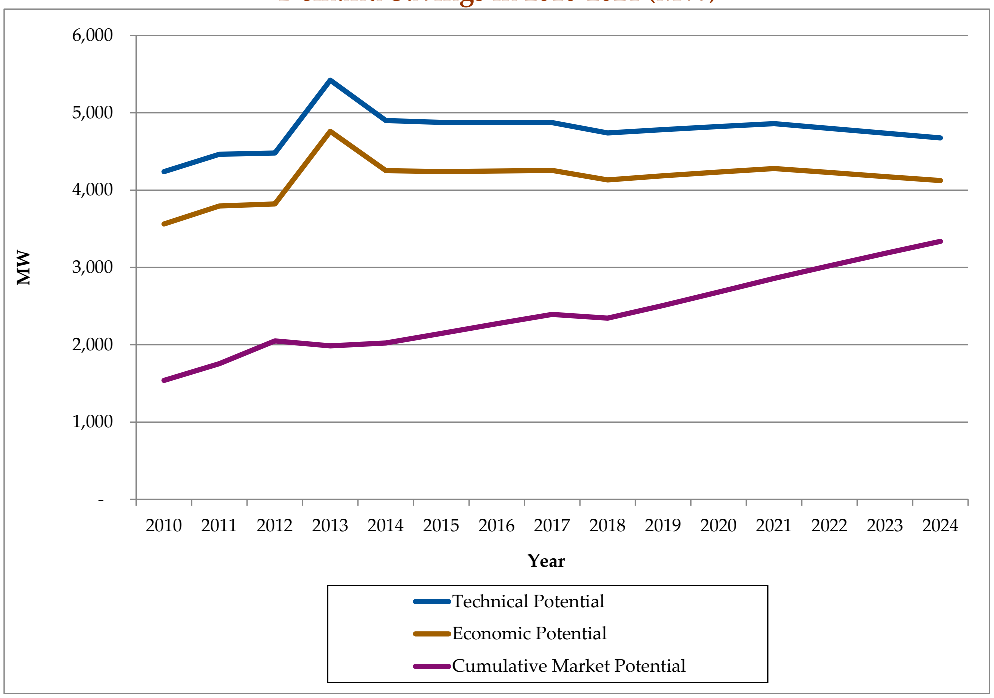
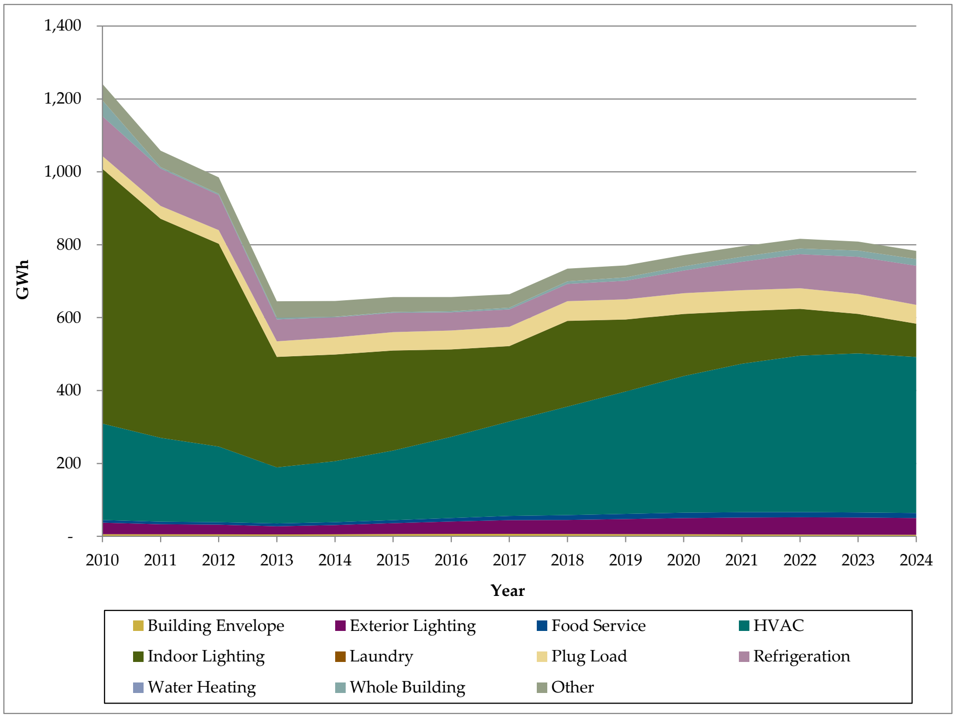


Figure 38 presents the incremental market potential for California's commercial sector, which decreases from 1,200 GWh in 2010 to a valley of approximately 650 GWh in between 2013 and 2017, before increasing back up to 800 GWh by 2024.

Figure 38. California Commercial Gross Incremental Market Energy Savings Potential by Measure (GWh)



This initial decrease in incremental market potential is due to codes and standards changes improving the baseline efficiency of commercial measures, hence decreasing measure use UES. Emerging technologies become a significant contributor to technical and economic potential for energy savings starting in 2013, which begins to correlate to higher market potential savings in 2017 as the market becomes more aware of and willing to implement these measures.

There is an increase in savings potential in 2018 due to increase in indoor lighting savings potential in 2018. This increase in potential is driven by increased savings potential for advanced generation (premium) T-8 lamps replacing standard T-8 lamps. Starting 2015, the baseline for linear fluorescent lamps shifts from T – 12 to T -8. By 2018, the model assumes that all existing T -12 lamps have been converted to standard T-8 lamps, thus making a much larger part of the population available for an upgrade to premium T-8 lamps. This leads to an increase in savings potential starting 2018.

Figure 39 presents the gross incremental market demand savings potential for the commercial sector. The incremental market demand potential follows a very similar trend to that of the incremental market energy potential. It starts high at around 350 MW in 2010, decreases to a valley around 150 MW between 2013 and 2017 before increasing back up to around 170 MW in 2024.

Figure 39. California Commercial Gross Incremental Demand Savings Market Potential for 2010-2024 (MW)

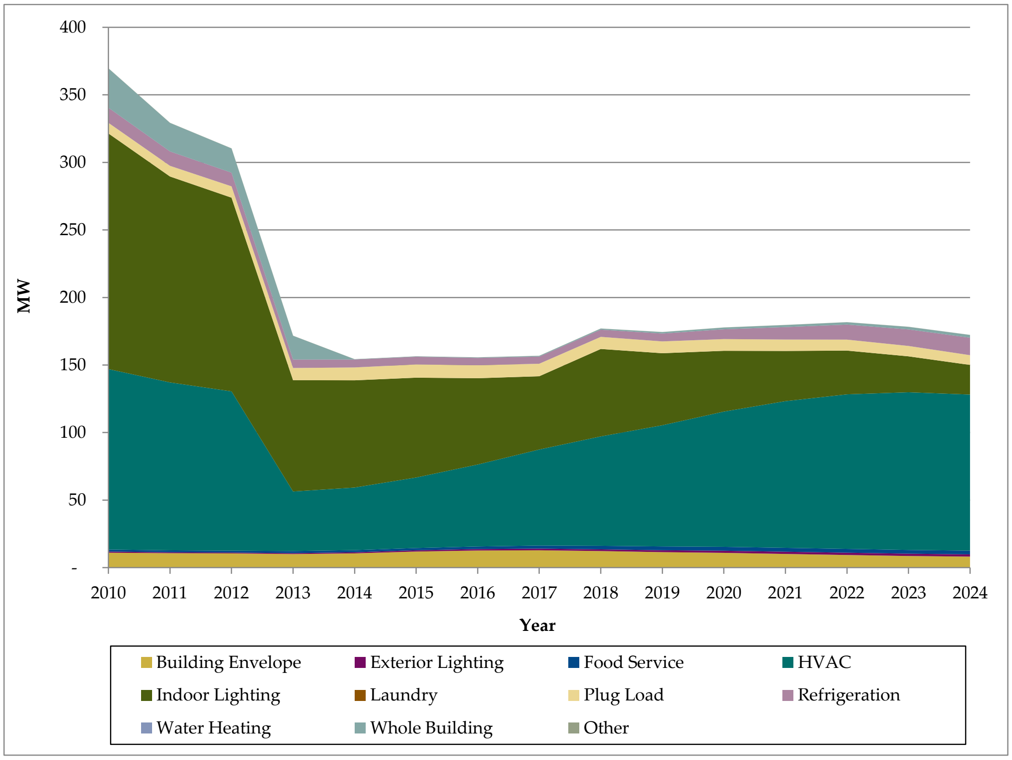


Figure 38 and Figure 39 break out the incremental market potential for energy and demand, respectively. Lighting, HVAC, and Refrigeration have the largest potential savings for both energy and demand. These figures show the effects of codes and standards on the potential savings. The biggest decrease comes in 2013 due to lighting standards that come into effect that year. The increase in savings potential in 2018 is due to increase in indoor lighting potential. This is explained in the text accompanying Figure 38, Section 7.2.1.

Table 38 compares the economic and technical potential estimates of the 2008 potential study[71] and the 2011 potential study. The technical and economic potentials calculated by the 2011 potential study are slightly higher in the earlier years and significantly higher in the later years than those calculated by the 2008 potential study. Reasons for these differences in estimates include:

- The 2011 potential study used ex post energy savings estimates while the 2008 potential study used ex-ante energy savings estimates.
- The 2011 potential study analyzed the impact of codes and standards changes on technical and economic potential; the details of these codes and standards changes were not fully known and understood at the time the 2008 potential study was conducted.
- The 2011 potential study included a large portfolio of emerging technologies that provide significant increases to the technical and economic potential in 2013.

[71] *"California Energy Efficiency Potential Study"* ITRON (2008); (www.calmac.org, CALMAC ID: PGE0264.01)

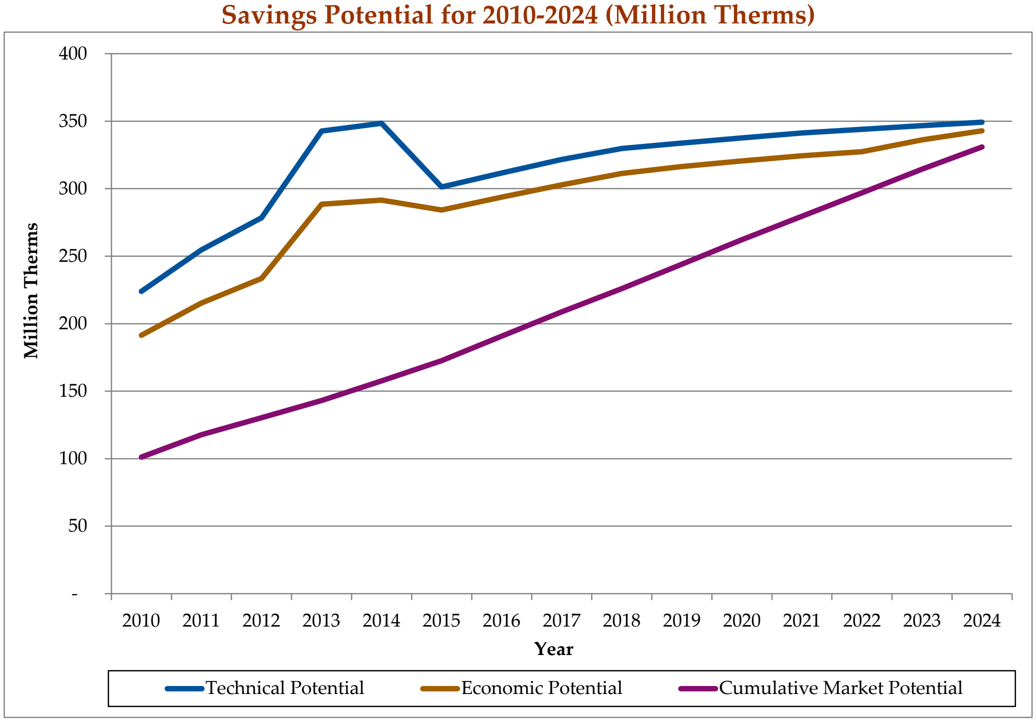
Table 38. Changes in California Commercial Technical and Economic Energy Potential from the Previous Forecast (GWh)

Year	Technical			Economic		
	2008 Study	2011 Study	Percent Increase or Decrease	2008 Study	2011 Study	Percent Increase or Decrease
2010	11,377	13,440	18%	10,179	12,387	22%
2011	11,964	13,195	10%	10,701	12,088	13%
2012	12,493	13,219	6%	11,157	12,153	9%
2013	12,963	17,519	35%	11,563	16,427	42%
2014	13,409	17,526	31%	11,945	16,485	38%
2015	13,824	17,511	27%	12,302	16,486	34%
2016	14,100	17,593	25%	12,514	16,585	33%

7.2.2 California Commercial Natural Gas Potential

California commercial gas technical energy savings potential varies from 225 million therms in 2010 to a approximately 350 million therms in 2024. The economic energy savings potential varies from approximately 200 million therms in 2010 to be almost equal to technical potential at just under 480 million therms in 2024. The cumulative market energy potential steadily increases from 100 million therms in 2010 to approximately 325 million therms in 2024. This is presented in Figure 40.

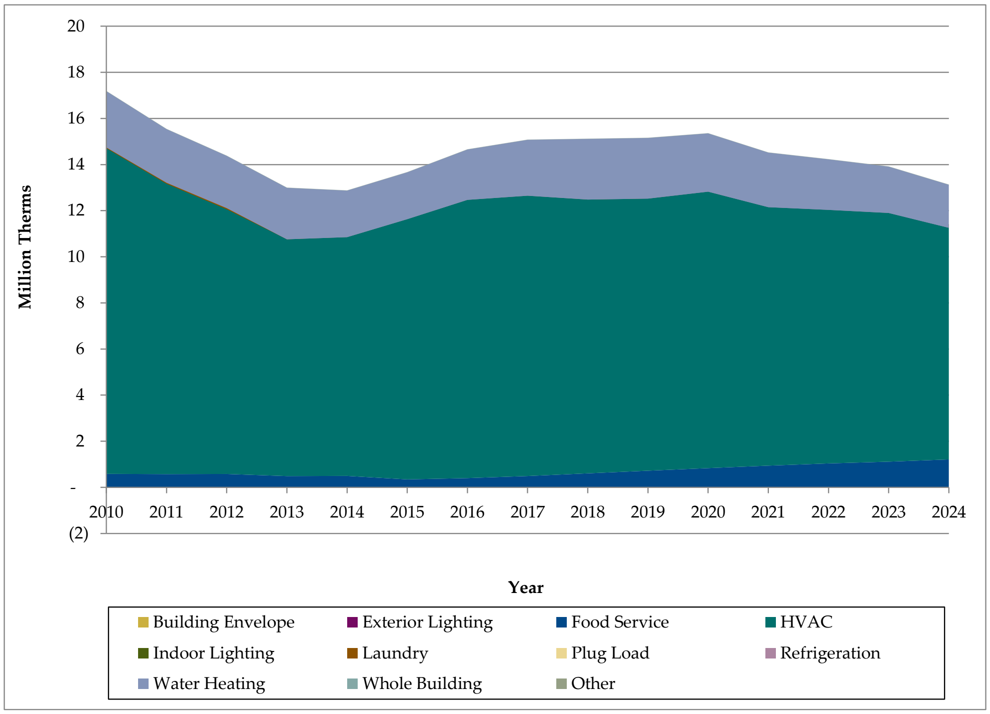
Figure 40. California Commercial Gross Technical, Economic, and Cumulative Market Gas Energy Savings Potential for 2010-2024 (Million Therms)



The increase in technical and economic potential in 2013 is due to the introduction of ETs to utilities' energy savings portfolio. The steady increase of cumulative market potential shows the steady increase in the market's awareness of and willingness to implement these ETs. There are fewer codes and standards on gas measures in the commercial sector, causing a decrease in potential in 2015, but not as dramatic of a decrease as for electric measures.

Figure 41 presents the gross incremental market potential in California from 2010 through 2024 for the commercial sector. The incremental gross market potential decreases from 17 million therms in 2010 to approximately 12 million therms in 2013 before increasing to 13 million therms in 2024. The decrease in savings from 2010 to 2013 is a continuation of the trending decrease in IOU claimed commercial sector gas savings from 2007 to 2010. In 2013 the trend reverses as certain existing technologies become more cost effective while new technologies become available. Figure 41 presents the gross incremental market potential in California from 2010 through 2024.

Figure 41. California Commercial Gross Incremental Market Potential for 2010-2024 (Million Therms)



8 Energy Efficiency Potential in California's Industrial Sector

This section provides the estimates of potential energy savings at the statewide level for the industrial sector.

8.1 Overview

The industrial technical and economic energy savings potential remains fairly flat from 2010 through 2024. This is primarily as the industrial sector is not affected by codes and standards or emerging technologies. Cumulative market energy savings potential increases between 2010 through 2024 due to cumulative addition of the market potential each year. The industrial sector was modeled using the same measure list and measure characteristics as the 2008 (ASSET) study. These inputs (ASSET) used for the industrial sector were the best available data at the time; this data is in need of an update to capture the change in industrial sector characteristics. This led to very similar projections of technical and economic potential between the 2008 and 2011 potential study.

8.2 California Industrial Summary of Results

8.2.1 California Industrial Electric Energy Potential

Economic and technical energy savings potential in the state of California stays steady between 5,000 and 6,000 GWh from 2010–2024. Cumulative market energy savings potential trails economic and technical energy savings potential and increases between around 1,300 GWh (in 2010) to around 4,300 GWh (in 2024) (Figure 42).

Figure 42. California Industrial Gross Technical, Economic, and Cumulative Market Energy Savings Potential for 2010-2024 (GWh)

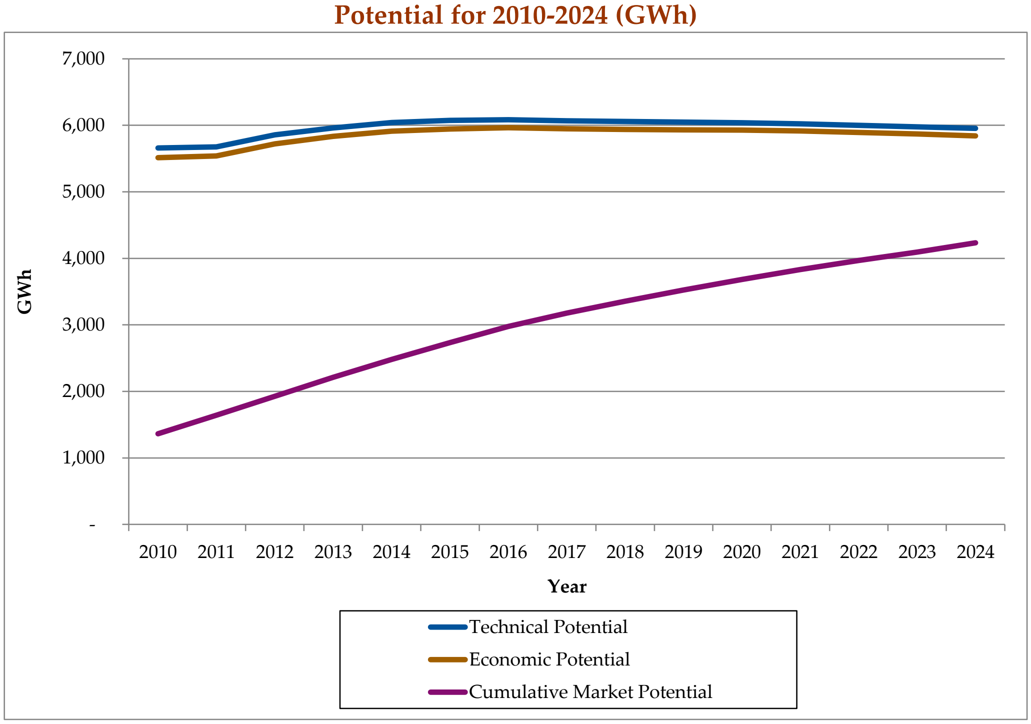


Figure 43 presents the total technical, economic and cumulative market demand savings potential through 2024. Technical and economic demand savings potential stay fairly flat (approximately 1,050 MW in 2010 and 1,100 MW in 2024); the cumulative potential increases from approximately 250 MW in 2010 to 800 MW in 2024.

Figure 43. California Industrial Gross Technical, Economic, and Cumulative Market Demand Savings Potential for 2010-2024 (MW)

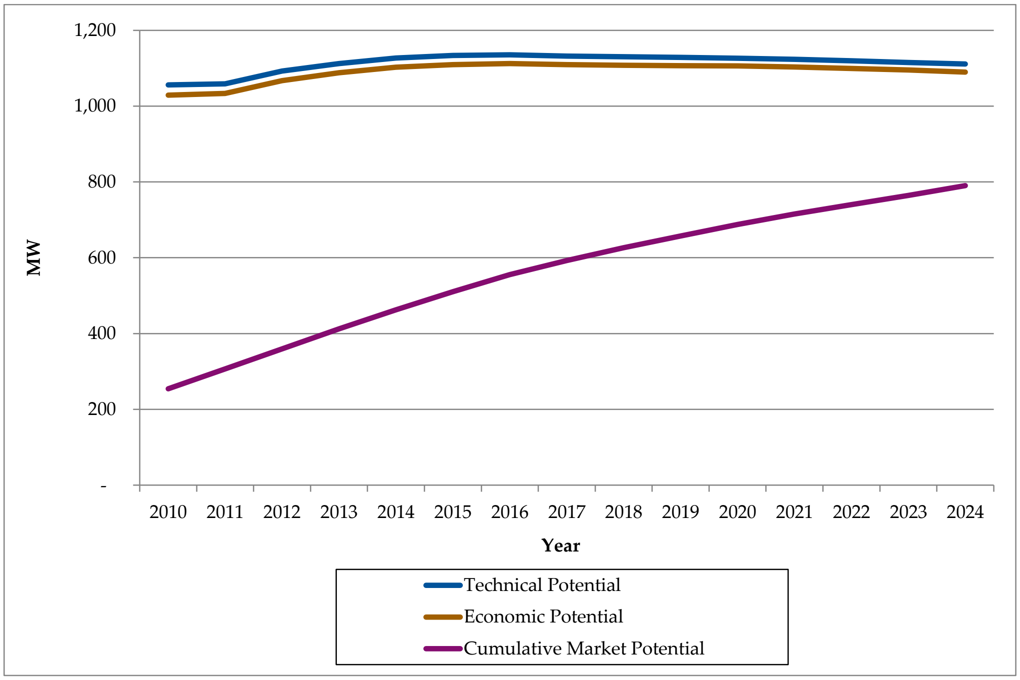


Figure 44 presents the incremental energy savings potential in the industrial sector. The incremental energy savings potential steadily decreases from 2013 (approximately 275 GWh) through 2024 (approximately 175 GWh). The majority of the savings in the industrial sector come from Industrial Process measures. Figure 45 presents the incremental demand savings potential in the industrial sector. The demand savings potential follows a similar trend to the energy savings potential, decreasing from approximately 53 MW in 2013 to approximately 33 MW in 2024.

Figure 44. California Industrial Gross Incremental Market Energy Savings Potential for 2010-2024 (GWh)

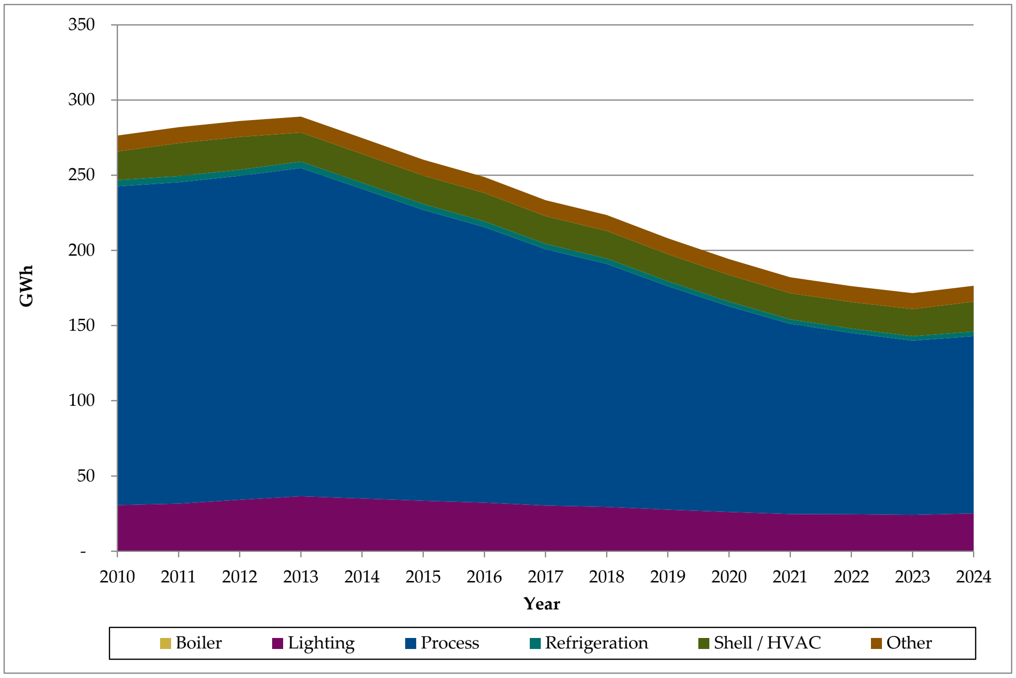


Figure 45. California Industrial Gross Incremental Market Demand Savings Potential for 2010-2024 (MW)

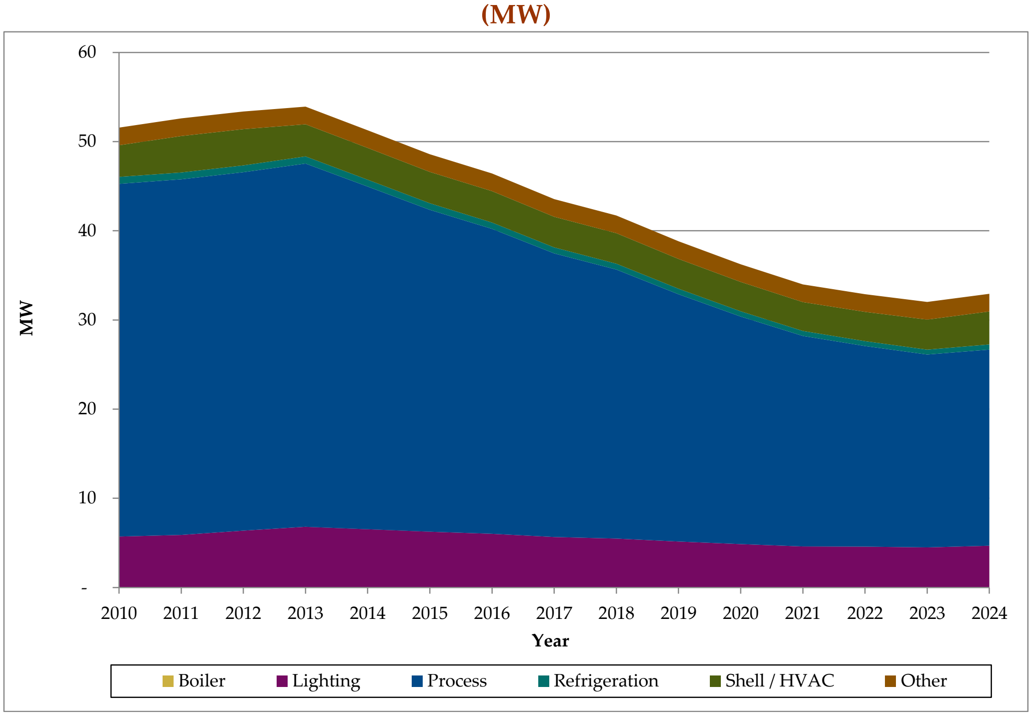


Table 39 presents a comparison of the technical and economic potential as calculated by the 2008 and the 2011 potential studies. The potential energy savings estimates as calculated by both studies are very similar. This is because the measure inputs used for both studies were the same. The slight difference in calculated energy savings potential is caused by differences in the structure of the two models used.

Table 39. Changes in California Industrial Technical and Economic Energy Potential from the Previous Forecast (GWh)

Year	Technical			Economic		
	2008 Study	2011 Study	Percent Increase or Decrease	2008 Study	2011 Study	Percent Increase or Decrease
2010	5,717	5,660	-1%	5,369	5,514	3%
2011	5,735	5,675	-1%	5,381	5,538	3%
2012	5,754	5,857	2%	5,395	5,720	6%
2013	5,776	5,962	3%	5,410	5,833	8%
2014	5,797	6,041	4%	5,426	5,912	9%
2015	5,819	6,075	4%	5,442	5,946	9%
2016	5,841	6,085	4%	5,458	5,963	9%

8.2.2 California Industrial Natural Gas Potential

Figure 46 presents the technical, economic, and cumulative market potential for gas energy savings in California in the industrial sector. All natural gas measures examined passed the TRC test; therefore, the technical and economic potentials are identical and range from around 415 million therms (in 2010) to approximately 500 therms (in 2024). The cumulative market potential lags the technical and economic potentials and increases from around 110 million therms (in 2010) to around 260 million therms (in 2024).

Figure 46. California Industrial Gross Technical, Economic, and Cumulative Market Gas Savings Potential for 2010-2024 (Million Therms)

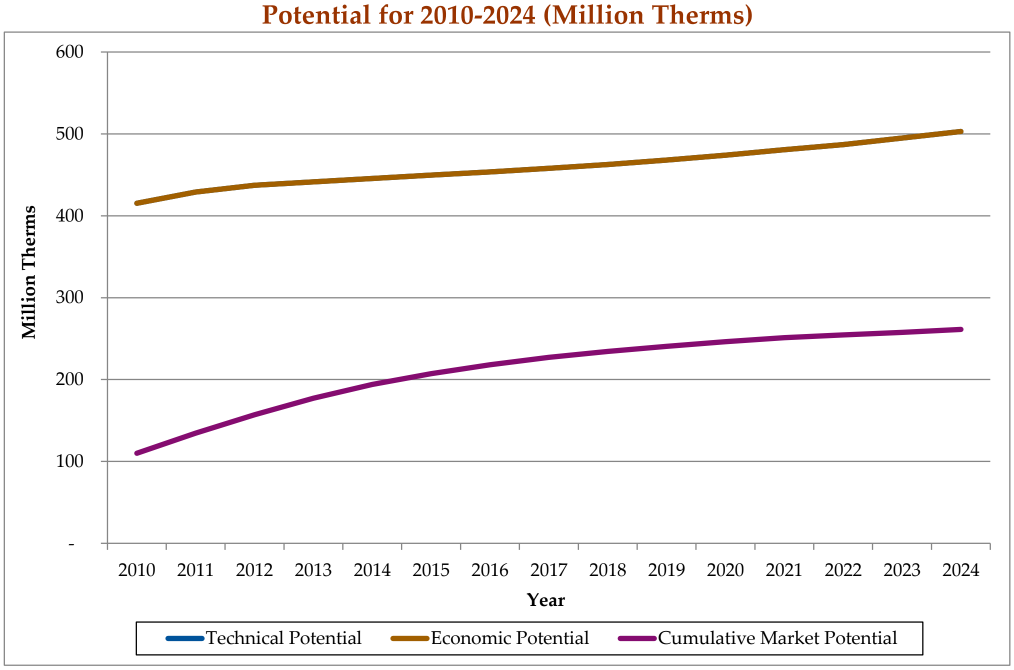
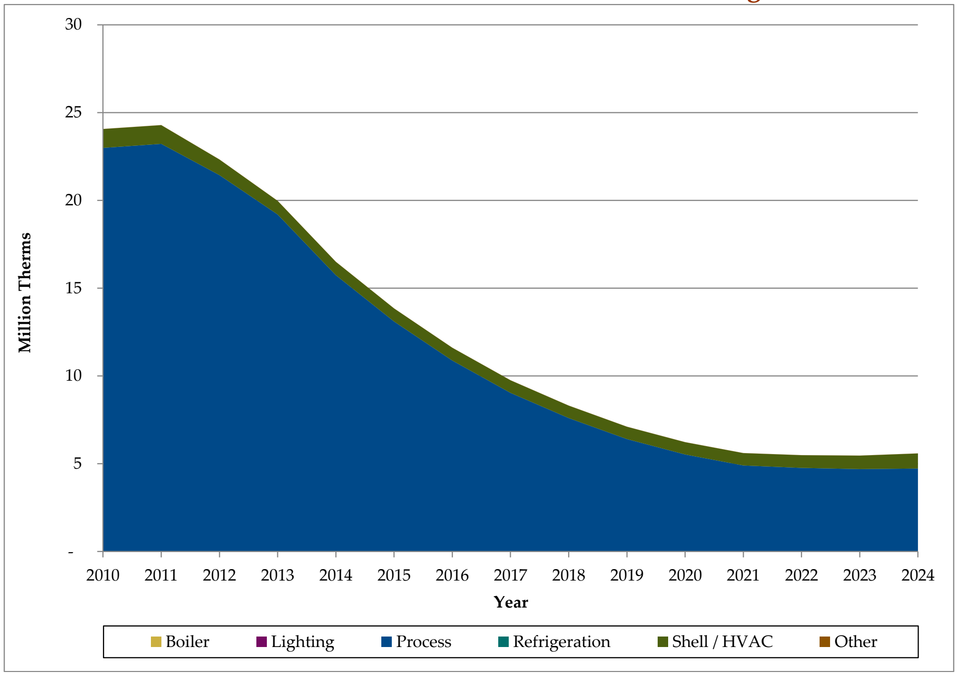


Figure 47 presents incremental market potential gas savings in the industrial sector through 2024. The incremental gas savings potential decreases steadily from 2010 (approximately 24 million therms), to 2024 (approximately 6 million therms).

Figure 47. California Industrial Gross Incremental Market Gas Savings Potential for 2010-2024



9 Energy Efficiency Potential in California's Agricultural Sector

This section provides the estimates of potential energy savings at the statewide level for agricultural operations contained within the examined NAICS designations.

9.1 *Overview*

The agricultural technical and economic energy savings potential remains fairly flat from 2010 through 2024. This is primarily because the agricultural sector is not affected by codes and standards or emerging technologies. Cumulative market energy savings potential increases between 2010 through 2024 due to cumulative addition of the market potential each year. The agricultural sector was modeled using IOU historic billing data and energy percentage savings estimates across different agricultural end uses. These percentage savings estimates were developed via secondary research and are documented in the Measure Input Characterization Sheets.

9.2 *California Agricultural Summary of Results*

9.2.1 California Agricultural Electric Energy Potential

Agricultural economic and technical energy savings potential in the state of California stays steady between 3,600 and 3,700 GWh for the 2010–2024 time period. Cumulative market energy savings potential trails economic and technical energy savings potential and increases between around 500 GWh (in 2010) to around 1,600 GWh (in 2024) (Figure 48).

Figure 48. California Agricultural Gross Technical, Economic, and Cumulative Market Energy Savings Potential for 2010-2024 (GWh)

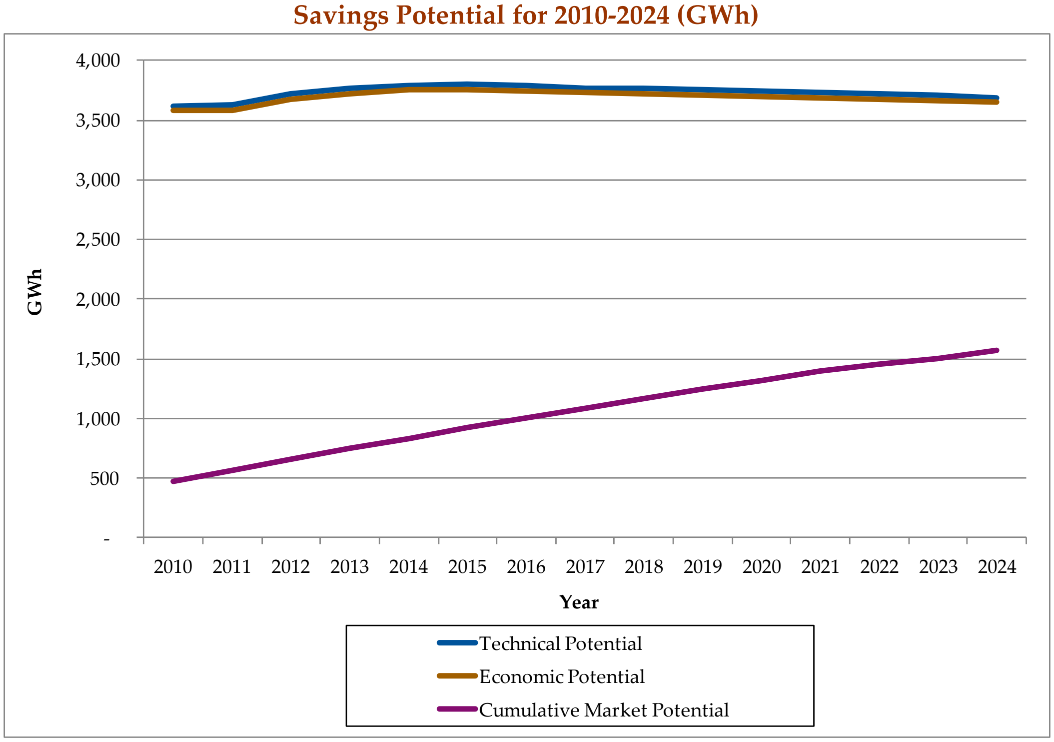


Figure 49 presents agricultural technical, economic, and cumulative market demand savings potential in the state of California. The technical and economic demand savings potential stay steady between 4,100 and 4,400 MW for the 2010–2024 time period. Cumulative market energy savings potential increases between around 50 MW (in 2010) to around 180 MW (in 2024)

Figure 49. California Agricultural Gross Technical, Economic, and Cumulative Market Demand Savings Potential for 2010-2024 (MW)

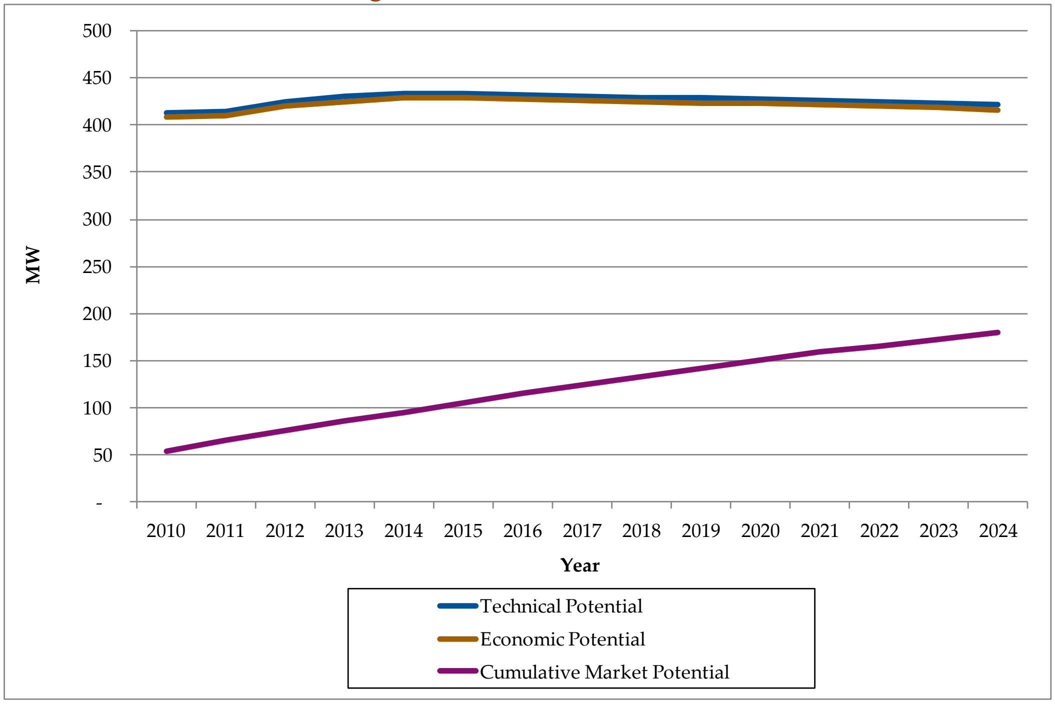


Figure 50 presents the incremental market energy savings potential in the agricultural sector in California. The incremental market potential decreases from 95 GWh in 2010 to approximately 80 GWh in 2024.

Figure 50. California Agricultural Gross Incremental Market Energy Savings Potential for 2010-2024 (GWh)

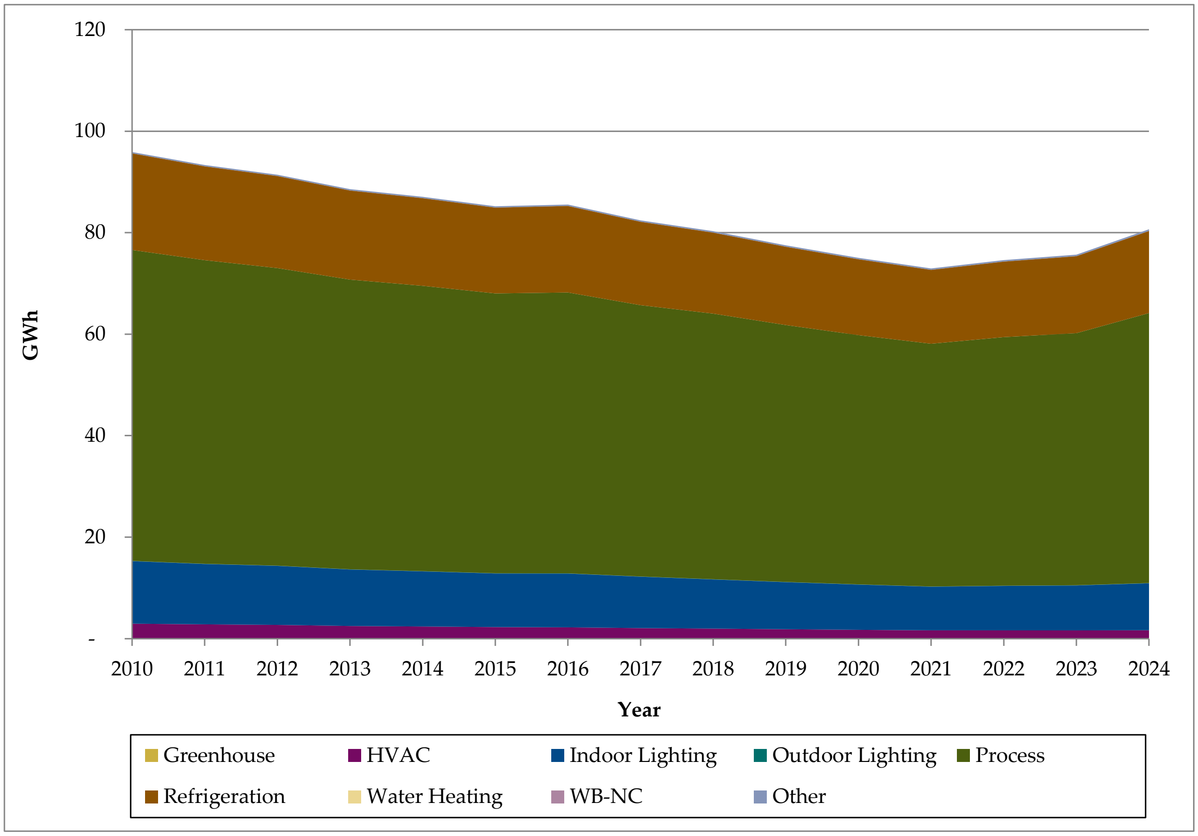


Figure 51 presents the incremental market demand savings potential in the agricultural sector in California. The incremental market potential decreases from 11 MW in 2010 to approximately 9 MW in 2024.

Figure 51. California Agricultural Gross Incremental Demand Savings Market Potential for 2010-2024 (MW)

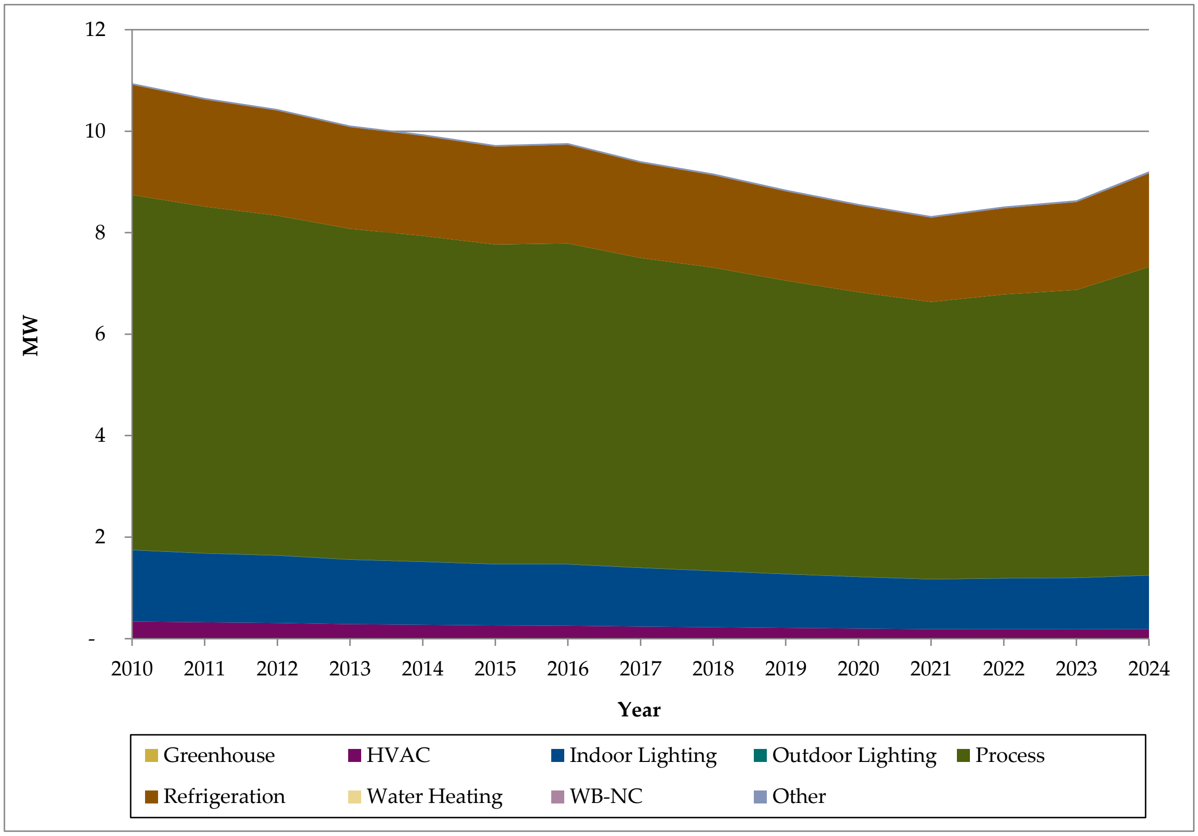


Figure 52 presents the technical, economic, and cumulative market potential for gas energy savings in California's agricultural sector. All natural gas measures examined passed the TRC test; therefore, the technical and economic potentials are identical and range from around 18 million therms (in 2010) to around 21 million therms (in 2024). Cumulative market potential lags economic and technical potential ranging from 4 million therms in 2010 to 11 million therms in 2024.

Figure 52. California Agricultural Gross Technical, Economic, and Cumulative Market Gas Savings Potential for 2010-2024 (Million Therms)

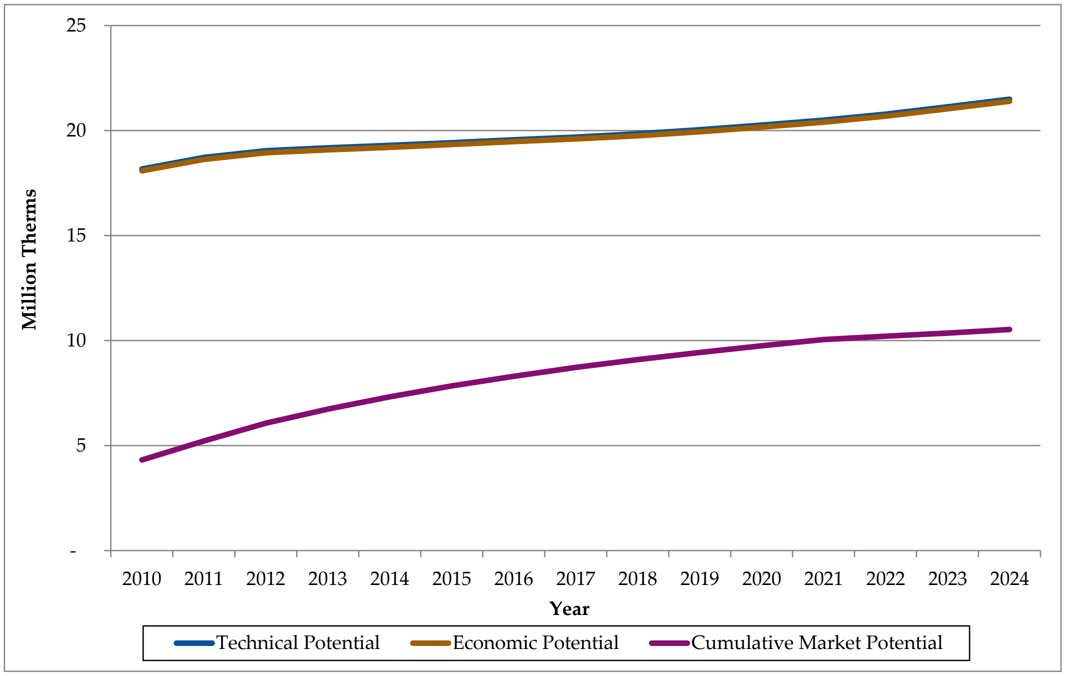
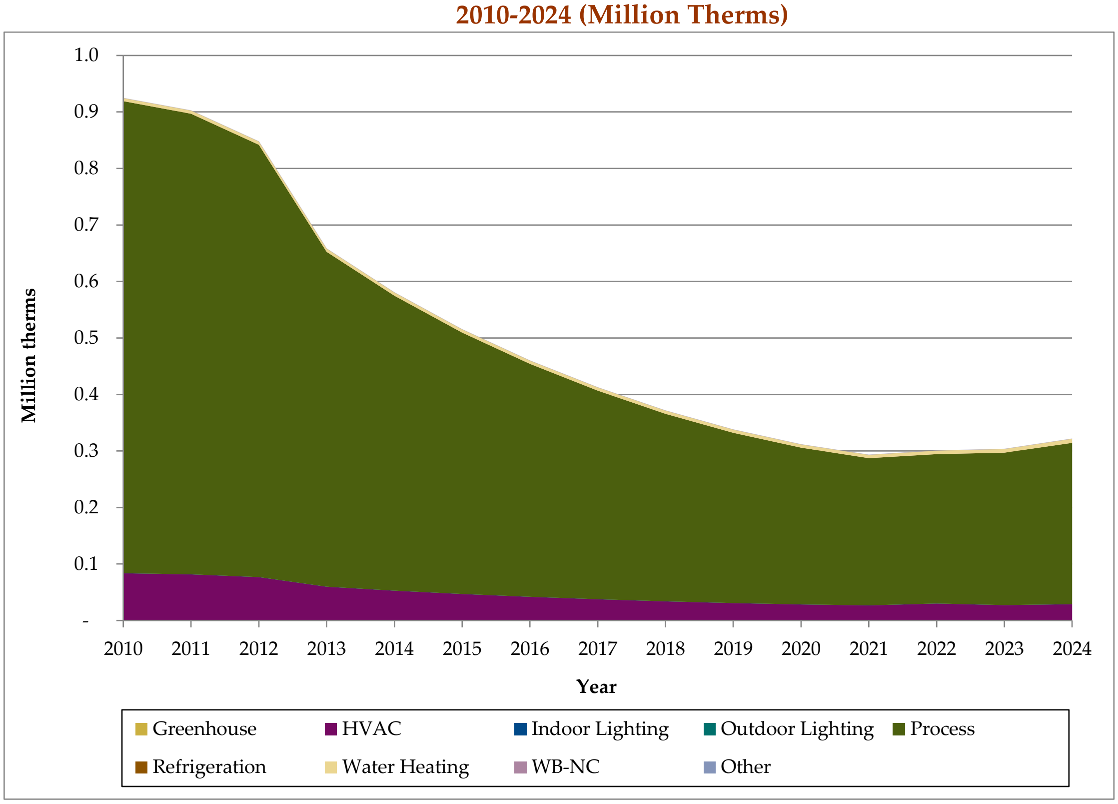


Figure 53presents the incremental market gas savings potential in the agricultural sector in California. The incremental market potential steadily decreases from 2010 (0.9 million therms) to 2024 (approximately 0.3 million therms).

Figure 53. California Agricultural Gross Incremental Market Gas Savings Potential by Measure for 2010-2024 (Million Therms)



10 Energy Efficiency Potential in the PG&E Service Territory

This section provides the estimates of potential energy savings for the entire PG&E service territory in the Residential, Commercial, Industrial, and Agricultural sectors for both electric and gas measures. Sector-specific trends for all utilities have been discussed in detail in Sections 6, 7, and 8, and utility-specific sector discussion is presented in Appendix A.

10.1 *Overview*

The potential energy savings in the PG&E territory is impacted significantly by upcoming codes and standards changes and the introduction of emerging technologies to utility portfolios. These impacts are explained in detail below.

10.2 *PG&E Area Summary of Results*

10.2.1 PG&E Total Electric Energy Potential

The technical potential in the PG&E territory varies from approximately 15,000 GWh in 2010, to just over 18,000 GWh in 2024. Economic potential is around 14,000 GWh in 2010, following a similar trend as technical potential to around 17,200 GWh in 2024. Cumulative market potential is around 7,500 GWh in 2010 and increases to approximately 13,500 GWh in 2024. Figure 54 presents the technical, economic, and cumulative market electric energy savings potential in PG&E's territory from 2010 through 2024.

Figure 54. PG&E Total Gross Technical, Economic, and Cumulative Market Potential for 2010-2024 (GWh)

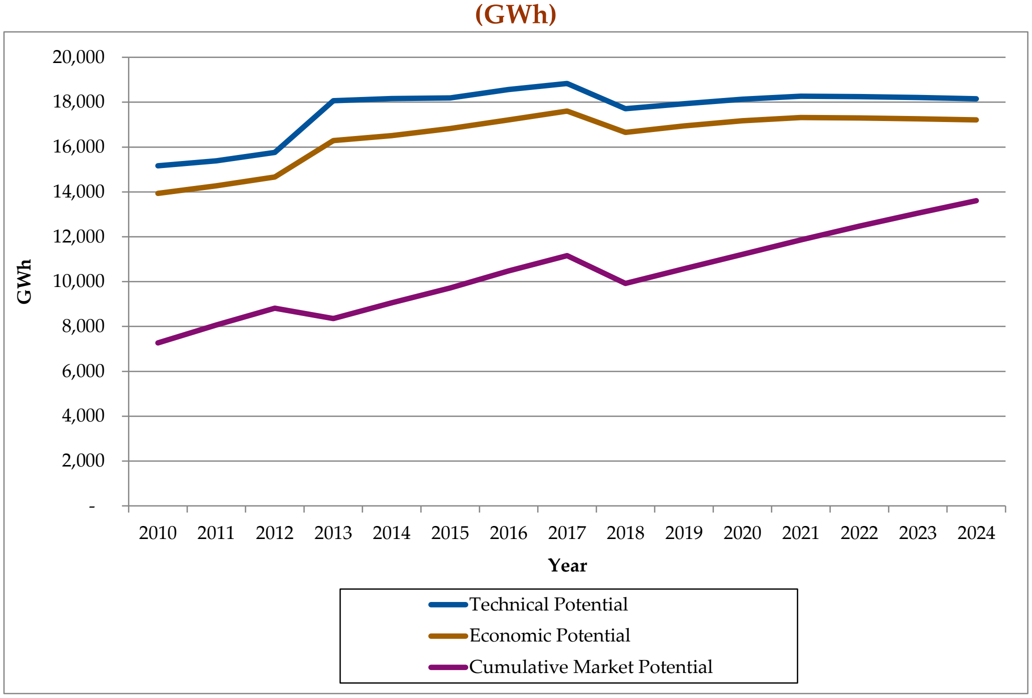


Figure 55 presents the technical, economic, and cumulative market electric demand savings potential for the PG&E territory over the years 2010 to 2024. Technical demand potential begins around 3,500 MW in 2010 and then jumps to over 4,500 MW in 2013, when many emerging technologies enter the market before it then drops (due to residential HVAC standards) and holds steady at around 4,000 MW for the remaining 10 years of the forecast period. Economic demand follows a similar line, remaining at roughly

80% of technical demand potential over the entire forecast, excepting the jump in 2013 due to the fact that many of these emerging technologies are not initially cost effective and therefore are not included in economic potential. Cumulative market potential begins just over 1,500 MW in 2010, increasing up to around 2,700 MW in 2024.

Figure 55. PG&E Total Gross Technical, Economic, and Cumulative Market Demand Potential for 2010-2024 (MW)

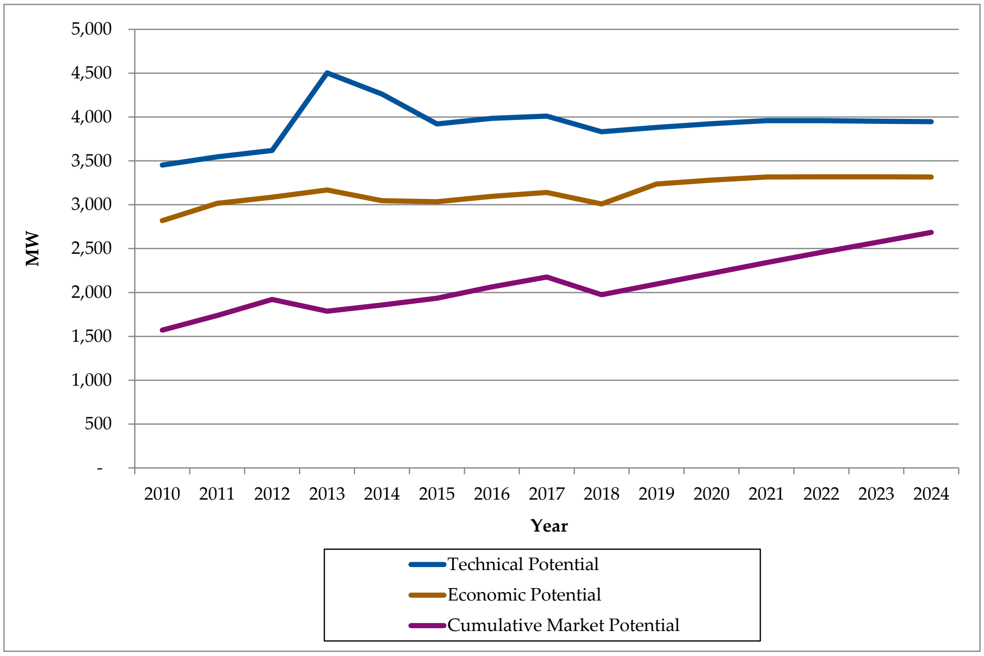


Figure 56 presents the incremental market potential for PG&E (in GWh) for 2010 to 2024. The incremental market potential follows a trend of sharp decline from 2010 (approximately 1,500 GWh) to 2013 and then begins a gradual decline to approximately 700 GWh in 2024.

Figure 56. PG&E Total Gross Incremental Market Potential for 2010-2024 (GWh)

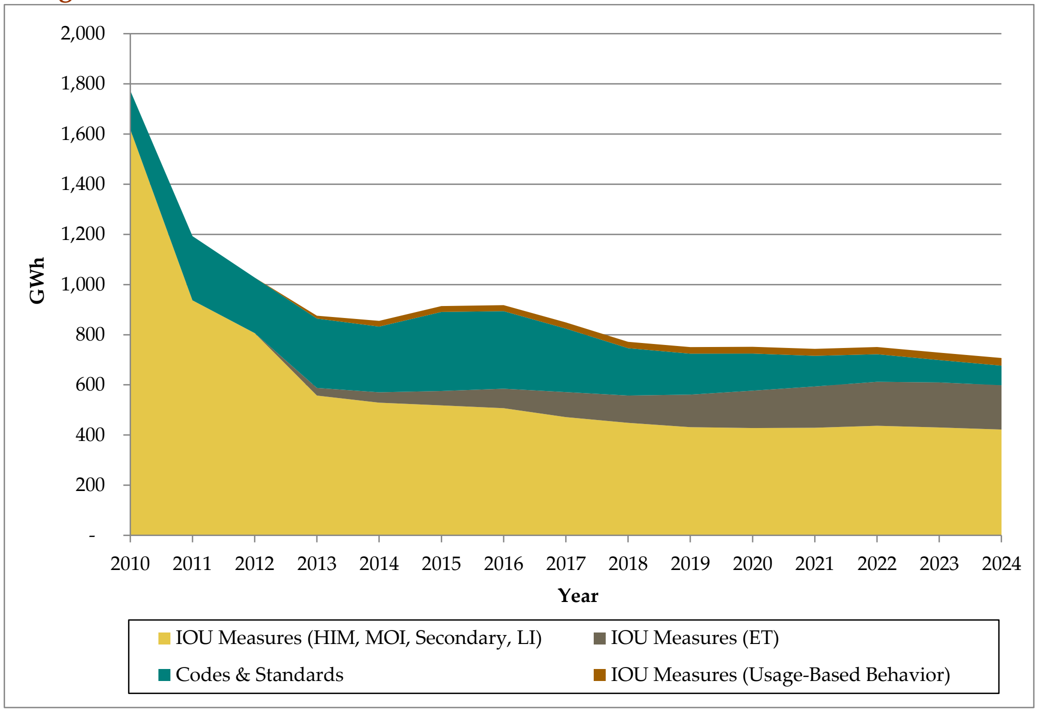


Figure 57 presents the incremental market demand potential for PG&E (in MW) for 2010 to 2024. The demand potential follows a similar trend to that of the energy savings, declining from 2010 (approximately 375 MW) to 2024 (approximately 125 MW).

Figure 57. PG&E Total Gross Incremental Market Potential for 2010-2024 (MW)

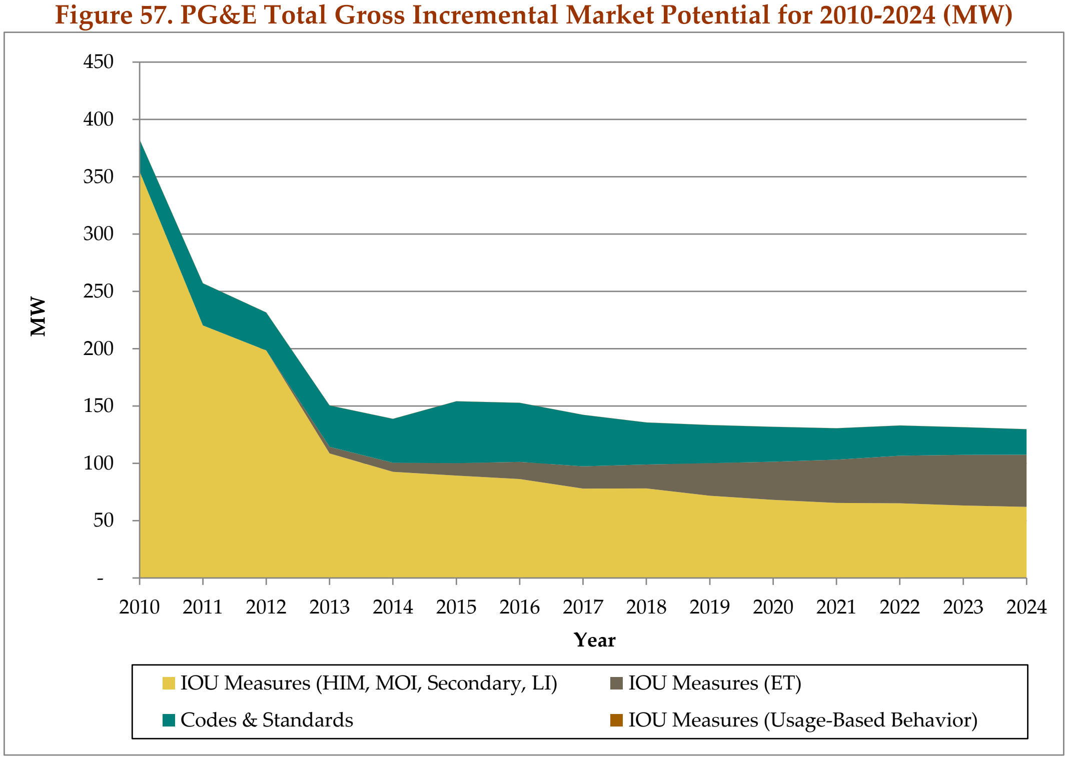


Figure 56 and Figure 57 break out the source of the incremental savings over the forecast period. Most of the potential in the early years comes from standard IOU Measures, such as HIMs, MOIs, secondary, and LI. Emerging Techonogies begin to have potential in 2013 and become the souce of nearly half of the incremental market savings from IOU measures by the end of the forecast. These figures also show the savings that can be attributed to codes and standards and usage-based behavior measures.

10.2.2 PG&E Natural Gas Potential

PG&E technical potential for gas savings varies between 675 million therms (in 2010) to approximately 900 million therms (in 2024). The economic potential stays between 70% and 85% of technical potential over the forecast period. Cumulative market potential has a steady increase between 75 million therms (in 2010) and 450 million therms (in 2024). This information is presented in Figure 58.

Figure 58. PG&E Total Gross Technical, Economic, and Cumulative Market Potential for 2010-2024 (Million Therms)

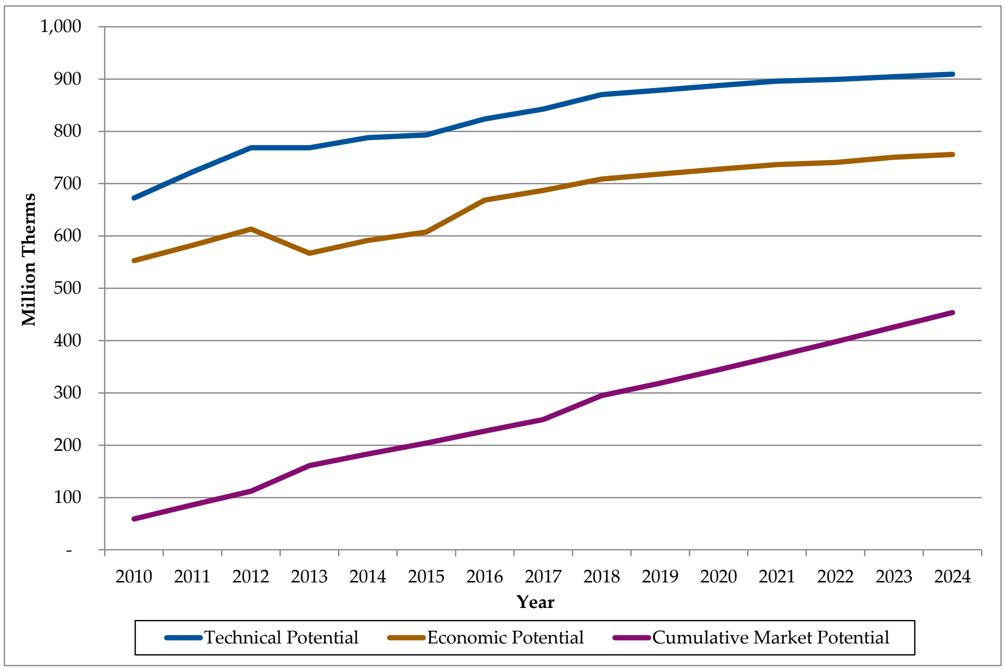
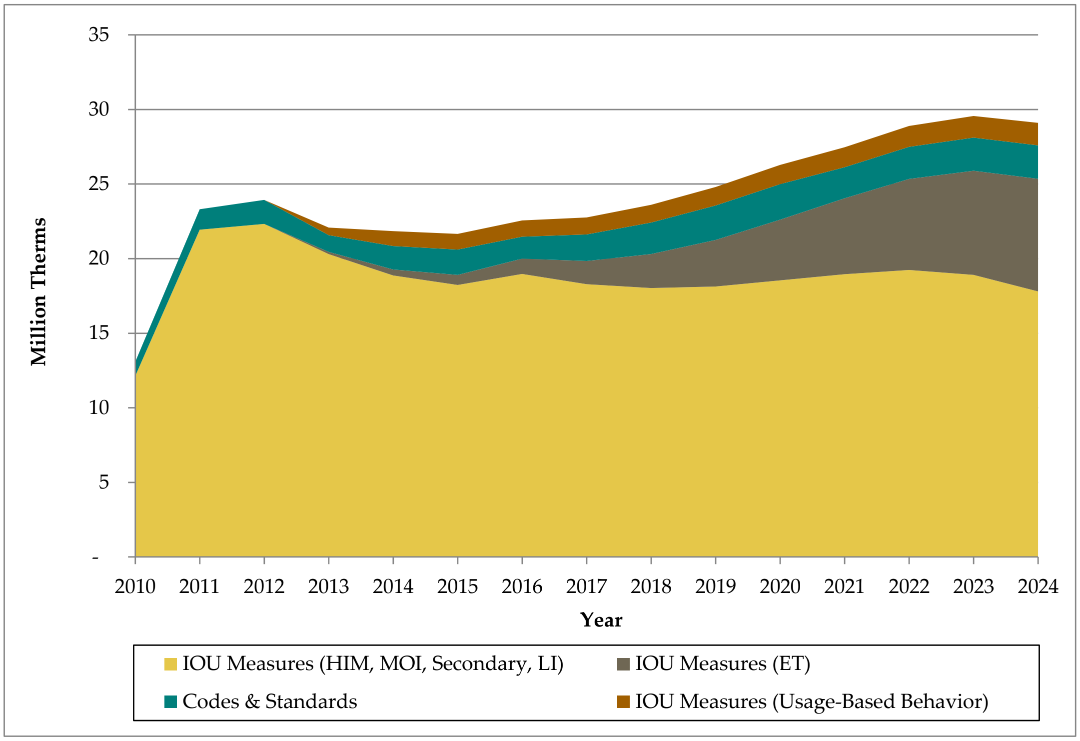


Figure 59 presents the residential incremental market potential for gas savings measures in the PG&E territory. Incremental market potential in 2010 is 13 million therms, and increases to a little approximately 29 million therms by 2024.

Figure 59. PG&E Total Gross Incremental Market Potential for 2010-2024 (Million Therms)



35
30
25
20
15
10
5
-
Million Therms
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
Year
IOU Measures (HIM, MOI, Secondary, LI)
IOU Measures (ET)
Codes & Standards
IOU Measures (Usage-Based Behavior)

11 Energy Efficiency Potential in the SCE Service Territory

This section provides the estimates of potential energy savings for the entire SCE service territory in the Residential, Commercial, Industrial, and Agricultural sectors for electric measures. Sector-specific trends for all utilities have been discussed in detail in Sections 6, 7, and 8, and utility-specific sector discussion is presented in Appendix A.

11.1 Overview

The potential energy savings in the SCE territory is impacted significantly by upcoming codes and standards changes and the introduction of emerging technologies to utility portfolios. These impacts are explained in detail below.

11.2 SCE Area Summary of Results

11.2.1 SCE Total Electric Energy Potential

The technical potential in the SCE territory varies from approximately 15,500 GWh in 2010 to just over 20,000 GWh in 2024. Economic potential begins around 14,000 GWh in 2010, following the same trend as technical potential to around 19,000 GWh in 2024. Cumulative market potential rises from around 6,500 GWh in 2010 to just under 15,000 GWh in 2024. Figure 60 presents the technical, economic, and cumulative market electric energy savings potential in SCE's territory from 2010 through 2024.

Figure 60. SCE Total Gross Technical, Economic, and Cumulative Market Potential for 2010-2024 (GWh)

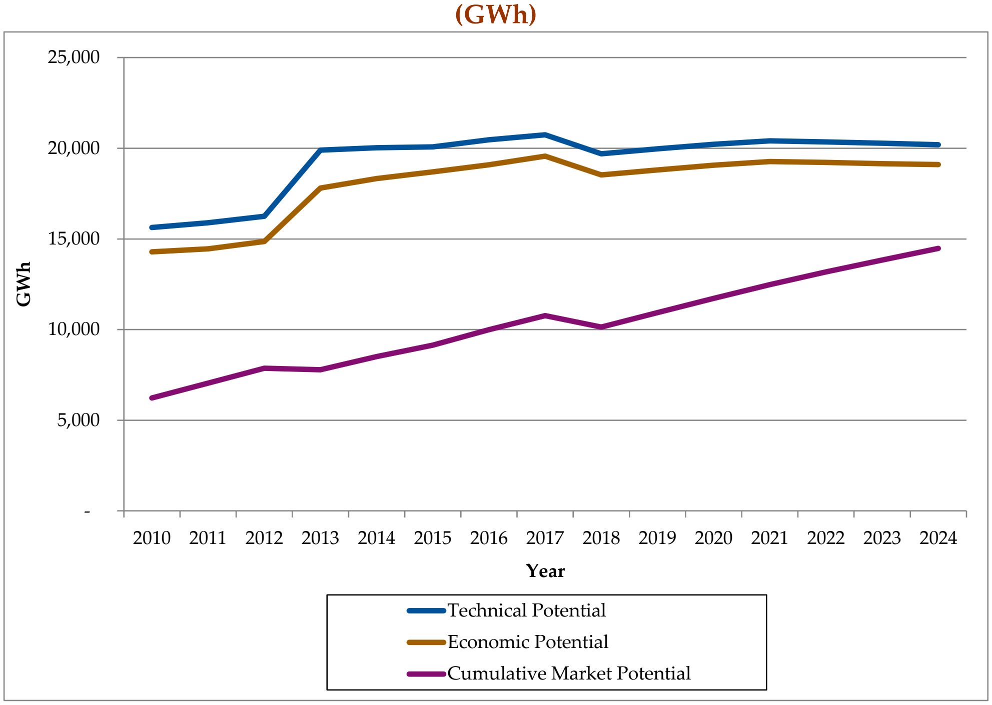


Figure 61 presents the technical, economic, and cumulative market demand savings potential for the SCE territory over the years 2010 to 2024. Technical demand potential begins around 4,700 MW in 2010, jumping to over 5,500 MW in 2013 when many emerging technologies enter the market, then falling slightly (due to residential HVAC standards) and leveling off at around 5,000 MW for the remaining 10 years of the forecast period. Economic demand follows a similar line, remaining at roughly 80% of technical demand potential over the entire forecast. Cumulative market demand potential follows the trend of the energy potential for cumulative market, increasing from 1,500 MW in 2010 to just over 3,000 MW in 2024.

Figure 61. SCE Total Gross Technical, Economic, and Cumulative Market Demand Potential for 2010-2024 (MW)

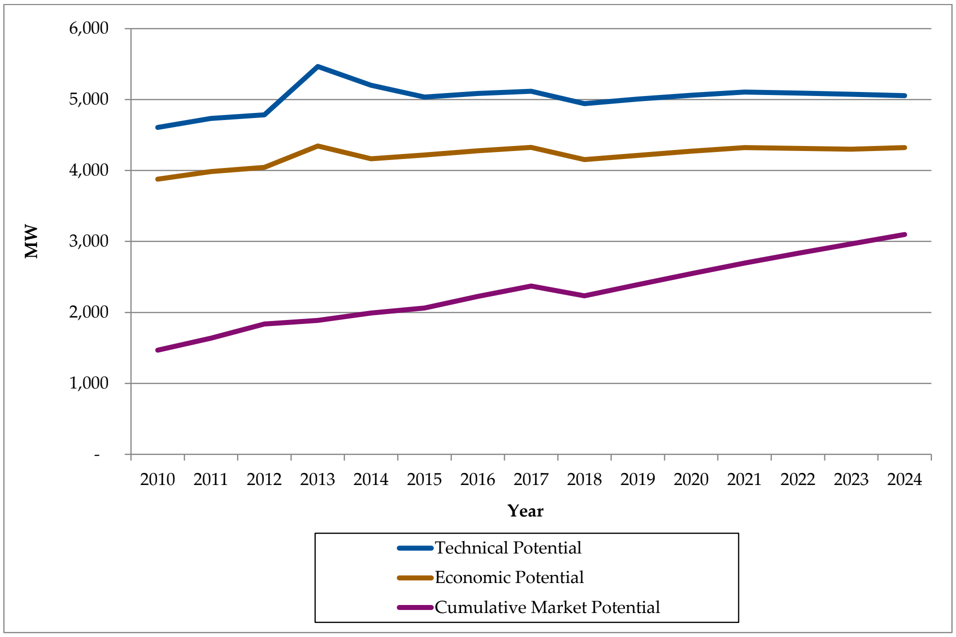


Figure 62 presents the incremental market potential for SCE (in GWh) for 2010 to 2024. The market potential follows a trend of gradual decline from 2010 (approximately 1,450 GWh) to 2024 (approximately 800 GWh), with a slight bump in 2014-2016 as emerging technologies start to have a significant impact. The increase in savings potential in 2018 for HIMs, is due to increase in commercial indoor lighting potential. This is explained in the text accompanying Figure 38, Section 7.2.1.

Figure 62. SCE Total Gross Incremental Market Potential for 2010-2024 (GWh)

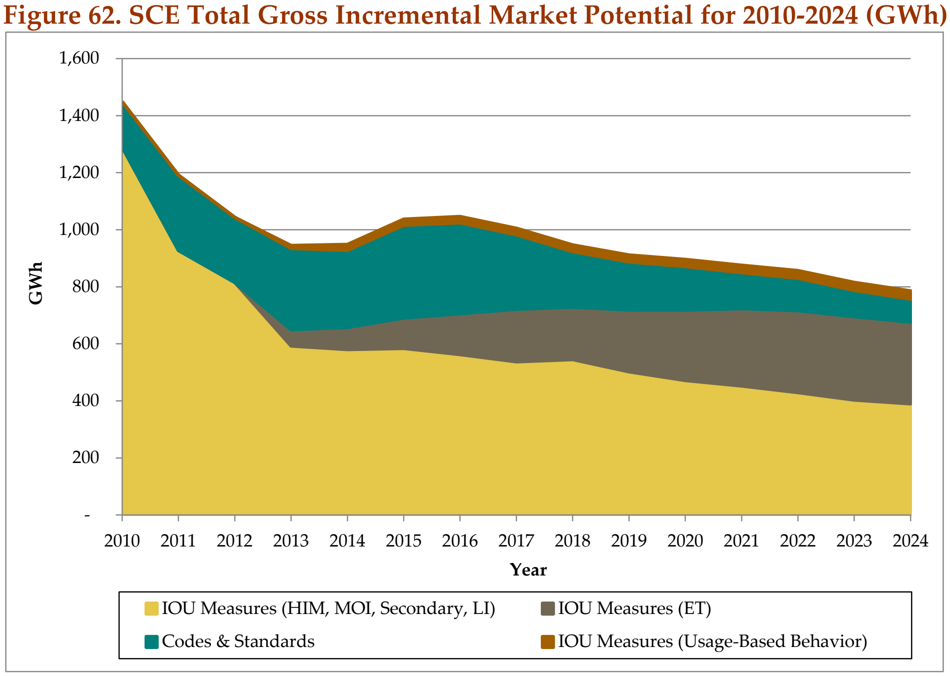


Figure 63 presents the incremental market demand potential for SCE (in MW) for 2010 to 2024. The demand potential follows a similar trend to that of the energy savings, declining from 2010 (approximately 350 MW) to 2024 (approximately 150 MW). The increase in savings potential in 2018 for HIMs, is due to increase in commercial indoor lighting potential. This is explained in the text accompanying Figure 38, Section 7.2.1.

Figure 63. SCE Total Gross Incremental Market Demand Potential for 2010-2024 (MW)

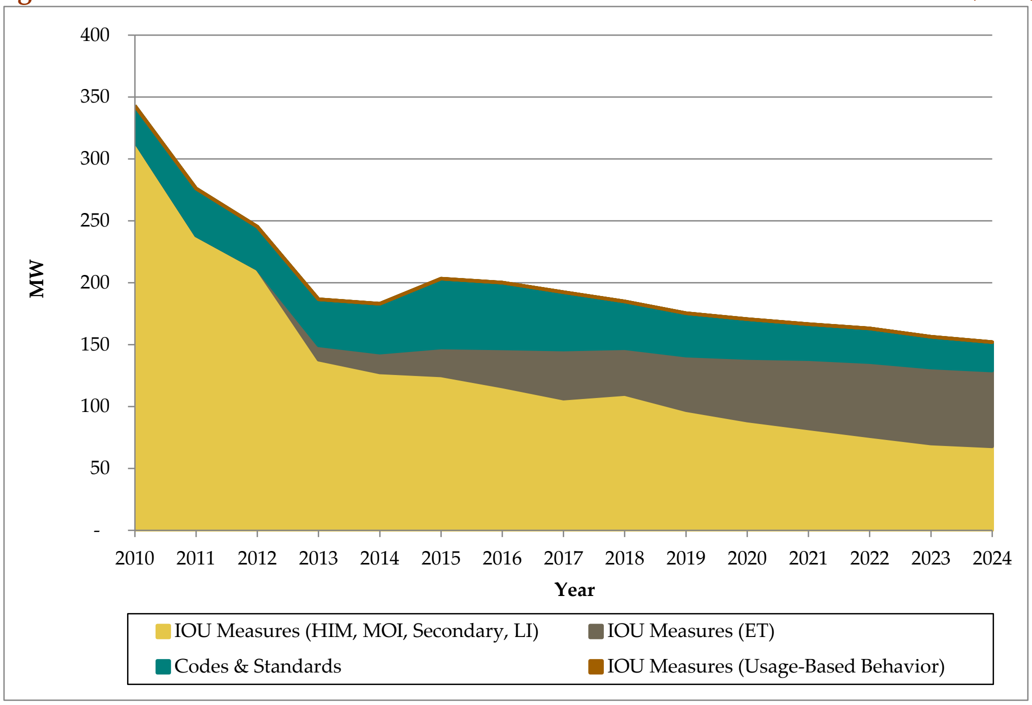


Figure 62 and Figure 63 break out the source of the incremental savings over the forecast period. Most of the potential in the early years comes from standard IOU measures, such as HIMs, MOIs, Secondary, and LI. Emerging Technologies begin to have potential in 2013 and become the souce of nearly half of the incremental market savings by the end of the forecast as they become more cost effective. These figures also show the savings that can be attributed to codes and standards and usage-based behavior measures. The increase in savings potential in 2018 for HIMs, is due to increase in commercial indoor lighting potential. This is explained in the text accompanying Figure 38, Section 7.2.1.

12 Energy Efficiency Potential in the SCG Service Territory

This section provides the estimates of potential therm savings for the entire SCG service territory in the Residential, Commercial, Industrial, and Agricultural sectors. Sector-specific trends for all utilities have been discussed in detail in Sections 6, 7, and 8, and utility-specific sector discussion is presented in Appendix A.

12.1 Overview

The potential therms savings in the SCG territory are explained in detail below.

12.2 SCG Area Summary of Results

12.2.1 SCG Total Gas Therms Potential

The technical potential in the SCG territory varies from approximately 525 million therms in 2010, to around 800 million therms in 2024. Economic potential is around 425 million therms in 2010, to just under 750 million therms in 2024. Cumulative market potential follows a steadily increasing trend from around 140 million therms in 2010 to approximately 480 million therms in 2024. Figure 64 presents these results.

Figure 64. SCG Total Gross Technical, Economic, and Cumulative Market Potential for 2010-2024 (Million Therms)

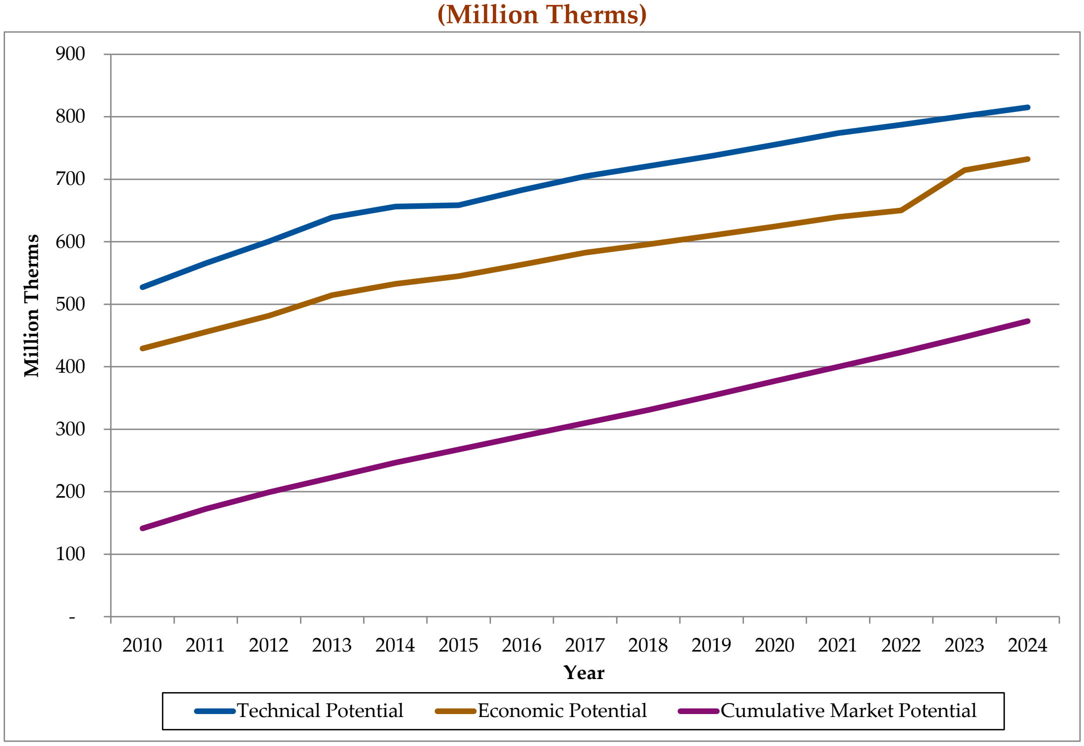
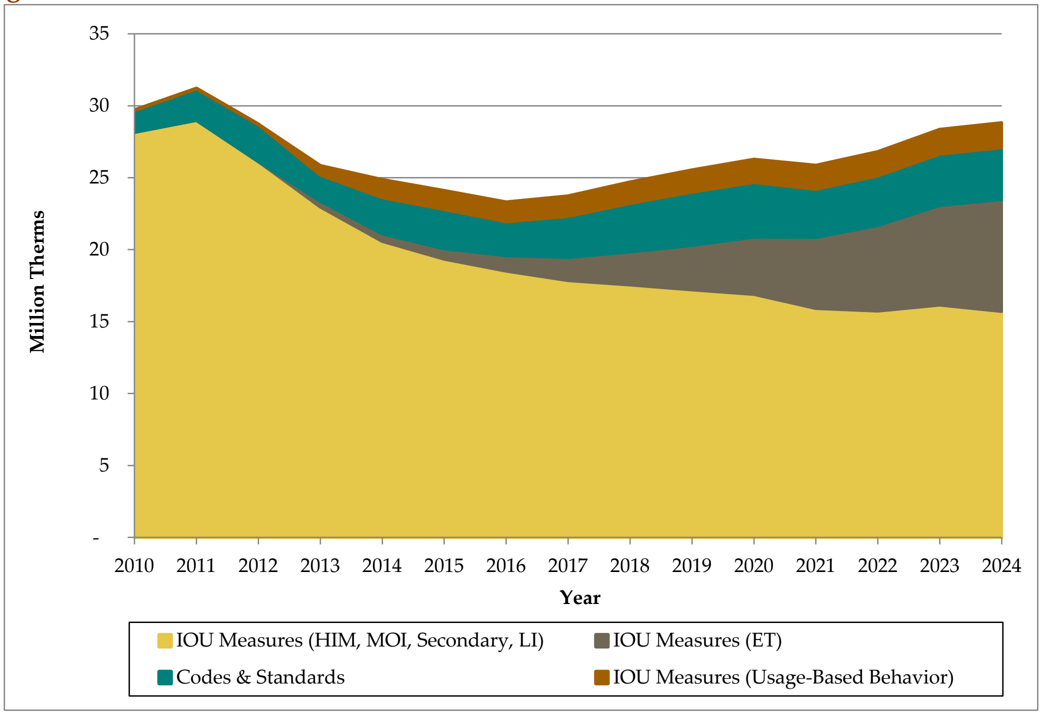


Figure 65 presents the incremental market potential for SCG (in millions of therms) for 2010 to 2024. The market potential starts out high in 2010 (approximately 30 million therms), slowly declining until 2016. More emerging technologies capture savings in 2019 and continue to capture more savings, increasing the incremental market potential up to around 28 million therms in 2024. This figure provides a break-out of the source of savings, showing savings from standard IOU measures, emerging technologies, usage-based behavioral programs, and codes and standards.

Figure 65. SCG Total Gross Incremental Market Potential for 2010-2024 (Million Therms)



13 Energy Efficiency Potential in the SDG&E Service Territory

This section provides the estimates of potential energy savings for the entire SDG&E service territory in the Residential, Commercial, Industrial, and Agricultural sectors for both electric and gas measures. Sector-specific trends for all utilities have been discussed in detail in Sections 6, 7, and 8, and utility-specific sector discussion is presented in Appendix A.

13.1 Overview

The potential energy savings in the SDG&E territory is impacted significantly by upcoming codes and standards changes and the introduction of emerging technologies to utility portfolios. These impacts are explained in detail below.

13.2 SDG&E Area Summary of Results

13.2.1 SDG&E Total Electric Energy Potential

The technical potential in the SDG&E territory varies from approximately 3,400 GWh in 2010, to around 4,100 GWh in 2024. Economic potential follows a very similar trend, increasing from 3,100 GWh in 2010 to just under 4,000 GWh in 2024. Cumulative market potential follows its own trend, increasing from 1,500 GWh in 2010 to 3,300 GWh in 2024. Figure 66 presents the technical, economic, and cumulative market electric energy savings potential in SDG&E's territory from 2010 through 2024.

Figure 66. SDG&E Total Gross Technical, Economic, and Cumulative Market Potential for 2010-2024 (GWh)

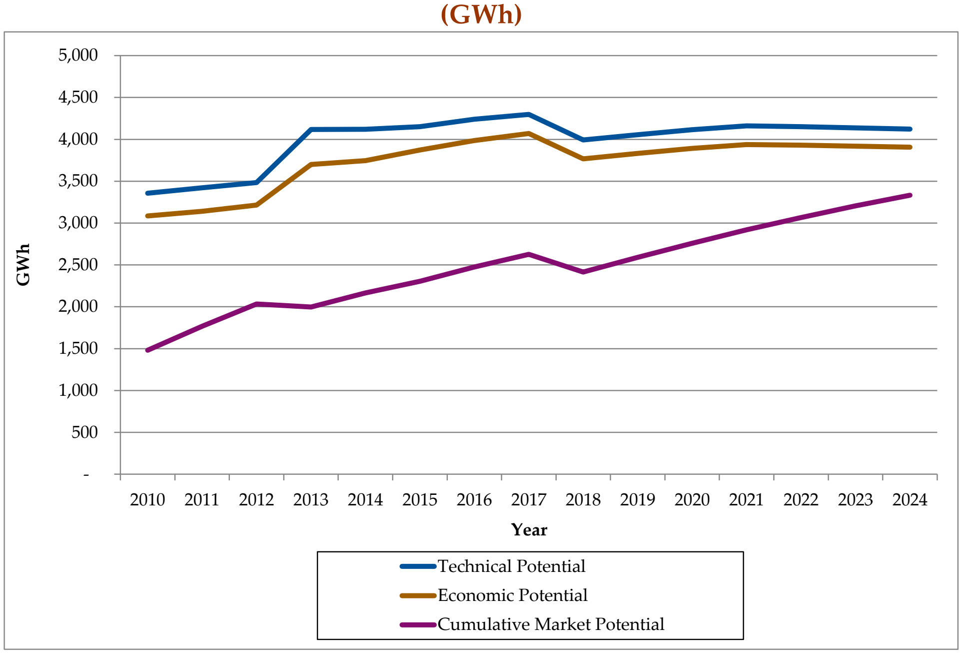


Figure 67 presents the technical, economic, and cumulative market electric demand savings potential for the SDG&E territory over the years 2010 to 2024. Technical demand potential begins around 800 MW in 2010 and peaks at around 1,100 MW in 2013, before declining again and flattening out to around 925 MW in 2024. This peak occurs as emerging technologies become available and the subsequent drop occurs as residential HVAC standards come into effect. Economic demand follows a similar line, remaining at roughly 80% of technical demand potential over the entire forecast. Cumulative market demand potential starts at 350 MW, increasing to around 700 MW in 2024.

Figure 67. SDG&E Total Gross Technical, Economic, and Cumulative Market Demand Potential for 2010-2024 (MW)

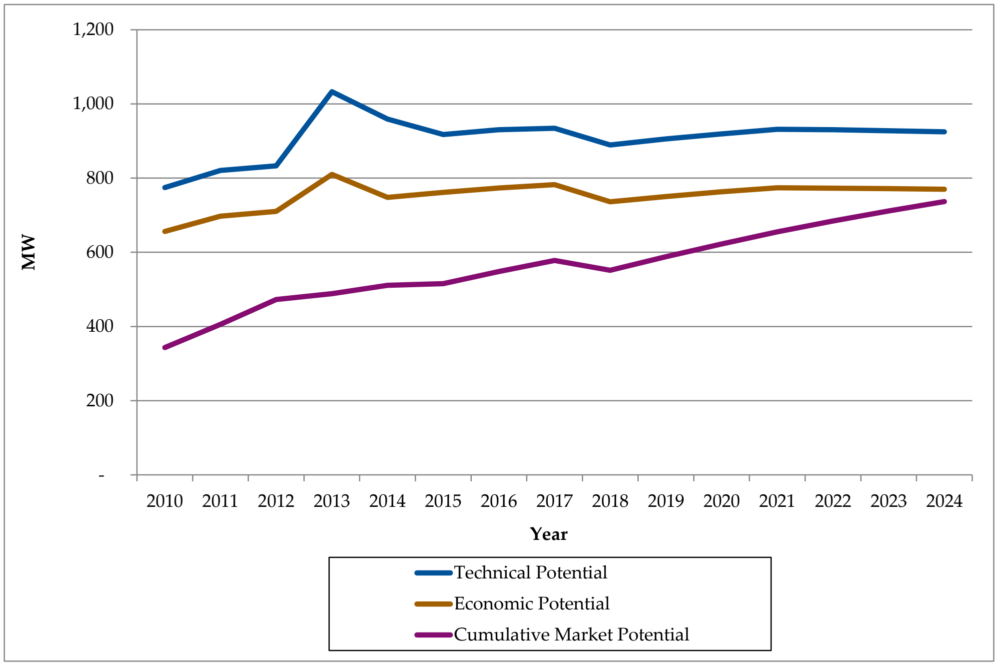


Figure 68 presents the incremental market potential for SDG&E (in GWh) for 2010 to 2024. The market potential trends downward from 2010 (approximately 390 GWh) to 2024 (approximately 150 GWh). The increase in savings potential in 2018 for HIMs, is due to increase in commercial indoor lighting potential. This is explained in the text accompanying Figure 38, Section 7.2.1.

Figure 68. SDG&E Total Gross Incremental Market Potential for 2010-2024 (GWh)

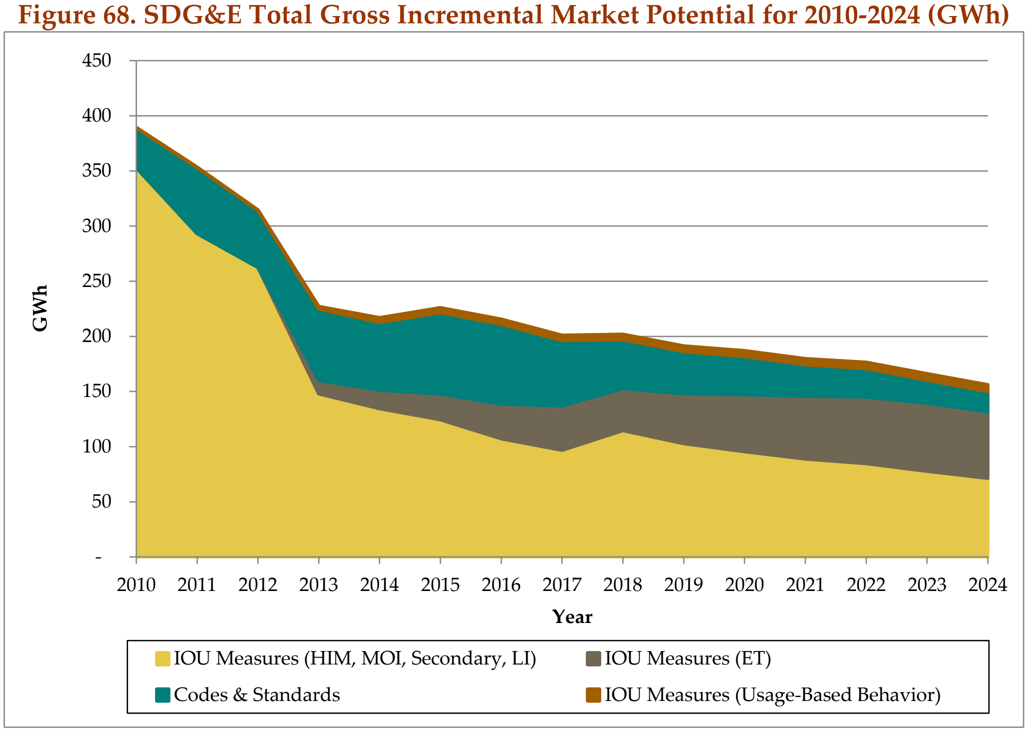
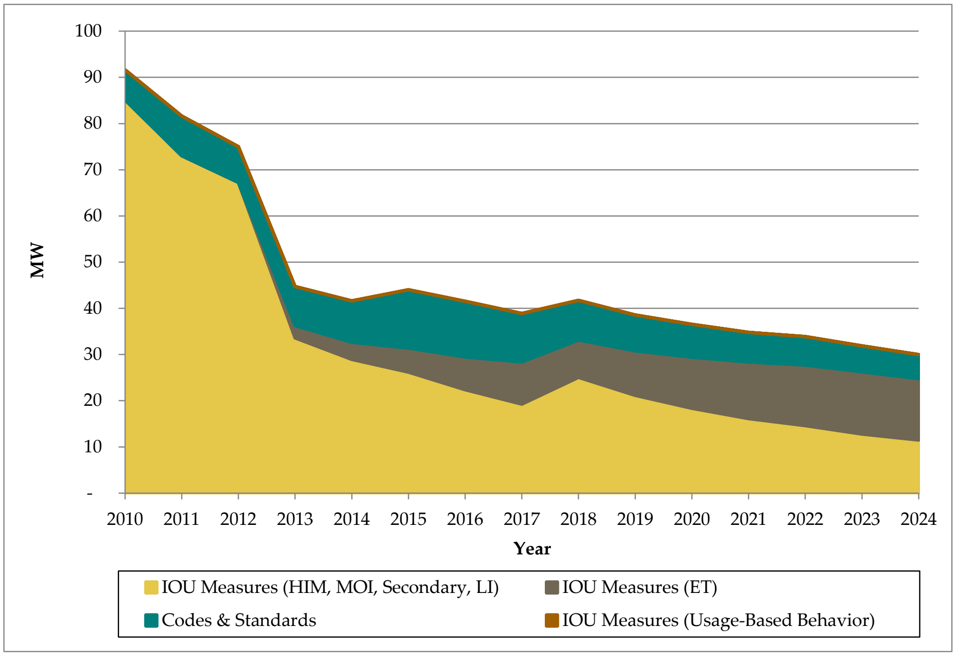


Figure 69 presents the incremental market demand potential for SDG&E (in MW) for 2010 to 2024. The demand potential follows a similar trend to that of the energy savings, declining from 2010 (approximately 90 MW) to 2024 (approximately 30 MW). The increase in savings potential in 2018 for HIMs, is due to increase in commercial indoor lighting potential. This is explained in the text accompanying Figure 38, Section 7.2.1.

Figure 69. SDG&E Total Gross Incremental Market Demand Potential for 2010-2024 (MW)



These two figures (Figure 68 and Figure 69) break out the source of the incremental savings over the forecast period. Most of the potential, especially in the early years, comes from standard IOU Measures, such as HIMs, MOIs, Secondary, and LI. Emerging Techonogies begin to have potential in 2013 and become the souce of nearly half of the incremental market savings by the end of the forecast. These figures also show the savings that can be attributed to codes and standards and usage-based behavior measures. The increase in savings potential in 2018 for HIMs, is due to increase in commercial indoor lighting potential. This is explained in the text accompanying Figure 38, Section 7.2.1.

13.2.2 SDG&E Natural Gas Potential

SDG&E technical potential for gas savings varies between 70 million therms (in 2010) to approximately 130 million therms (in 2024). The economic potential begins at approximately 65% of technical potential, and increases to around 75% of technical potential by 2024. Cumulative market potential increases from approximately 10 million therms in 2010 to 60 million therms in 2024. This information is presented in Figure 70.

Figure 70. SDG&E Total Gross Technical, Economic, and Cumulative Market Potential for 2010-2024 (Million Therms)

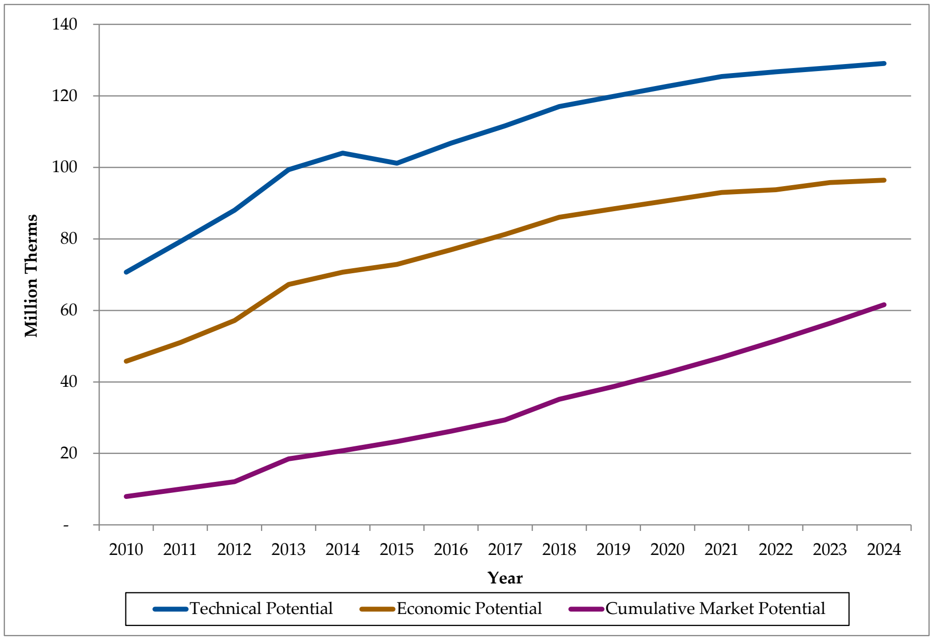
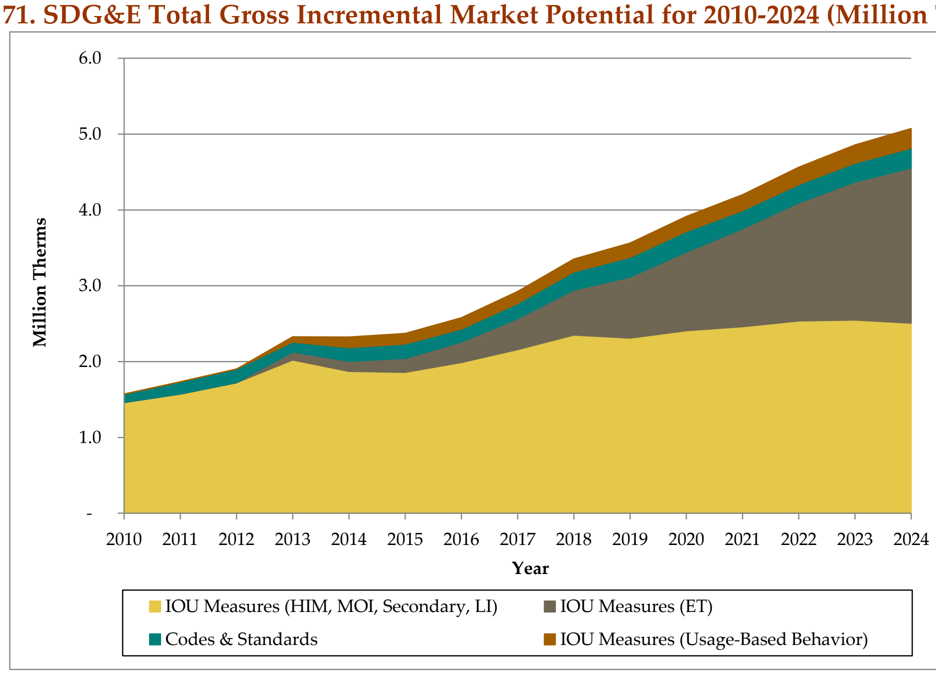


Figure 71 presents the residential incremental market potential for gas savings measures in the SDG&E territory. Incremental market potential in 2010 is approximately 1.5 million therms in 2010, increasing to just over 5 million therms in 2024.

Figure 71. SDG&E Total Gross Incremental Market Potential for 2010-2024 (Million Therms)



In SDGE service territory, ultra-high-efficiency water heating measures become cost effective in the later years. This causes the incremental market potential to keep increasing through 2024. In addition, the adoption of emerging technologies causes a large increase in incremental market potential in the later years of the forecast.

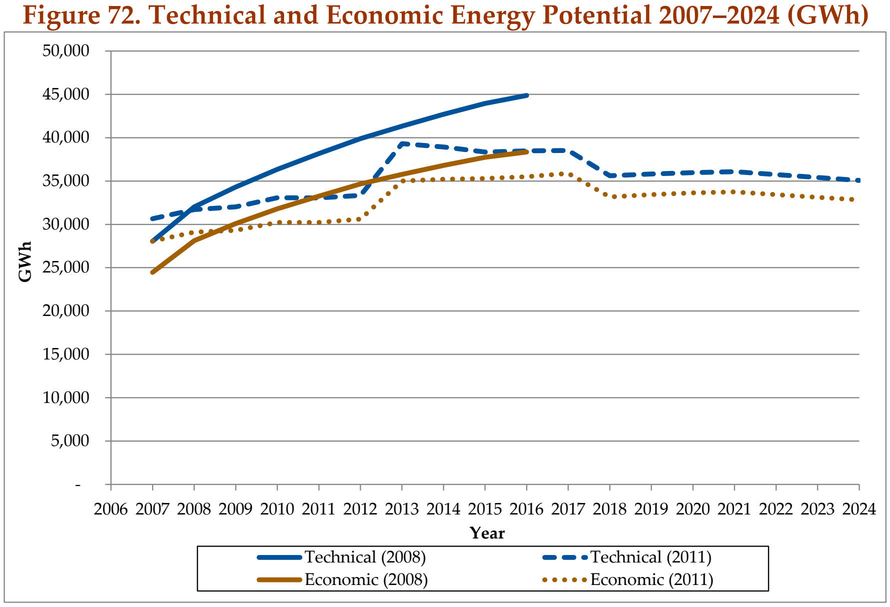
14 Summary of Findings, Recommendations, and Next Steps

14.1 Summary of Findings

The technical and economic potential, illustrated in Figure 2 below, represents the trend in the total energy savings available each year that are above the baseline of the California Title 20/24 codes and federal appliance standards. The technical potential is an aggregation of energy savings from all measures that are technically feasible in each market sector, while economic potential is limited to only measures that are cost effective based on the total resource cost test[72].

The 2011 potential study found a leveling off of available technical and economic potential through 2024. Figure 72 shows the difference in technical and economic energy potential (GWh) between the 2008 and 2011 potential studies, for the period from 2007 through 2016,[73] and also the 2011 forecast extending to 2024. Both technical and economic potential forecasts are adjusted downward in all comparison years after 2008. The forecast potential in Figure 2 is a cumulative value showing increases in some years and decreases in others. The fluctuations are primarily due to the implementation of changes in codes and standards (C&S) that shifts the potential for EE savings out of EE voluntary programs and into codes and standards savings forecasts, as well as the introduction of emerging technologies that become viable at different times. The 2011 report ended its forecast in 2024, with technical and economic potential in that year estimated at approximately 35,000 and 33,000[74], respectively, compared with the 2008 potential study, which estimated technical and economic potential in the year 2026 at 50,610 and 42,278 GWh respectively.

Figure 72. Technical and Economic Energy Potential 2007–2024 (GWh)



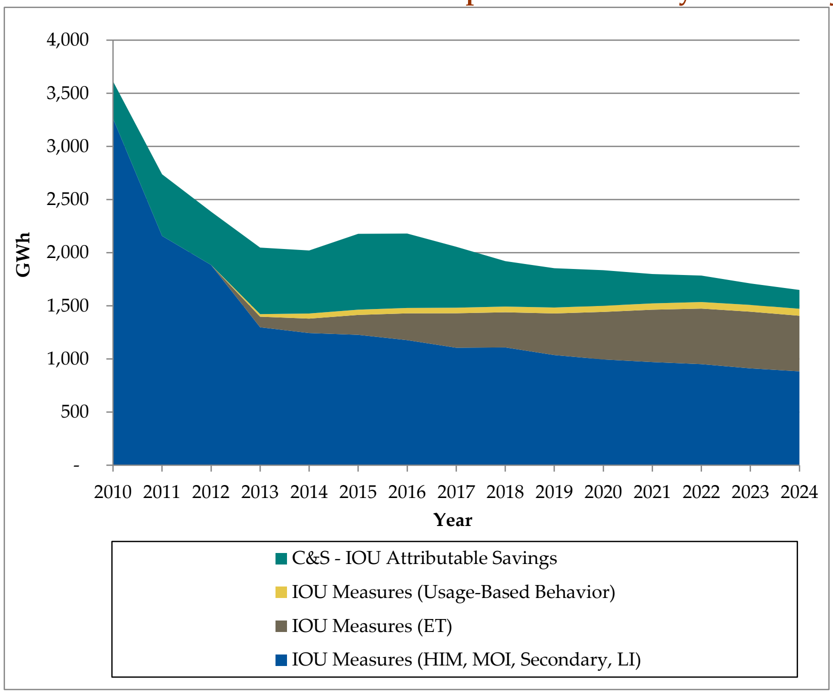
[72] The Total Resource Cost Test (TRC) is defined in the Energy Efficiency Standard Practice Manual, p. 18, which can be found at http://www.energy.ca.gov/greenbuilding/documents/background/07-J_CPUC_STANDARD_PRACTICE_MANUAL.PDF

[73] The period 2007 through 2016 was chosen as this was the time frame over which the forecasts for technical and economic potential could be compared between the 2008 and 2011 studies. The 2008 potential study forecast horizon was 2026, while the 2011 potential study horizon was 2024.

[74] The estimates of technical and economic potential for the 2011 potential study shown in Figure 2 do not include the impacts of codes and standards because codes and standards are not included in the 2008 potential study.

Figure 73 shows the forecast of incremental annual market potential from 2010 through 2024 by measure type. As discussed previously, during the period from 2010 through 2017 the 2011 potential study has found a generally consistent shift in incremental market potential between what can be installed through voluntary energy efficiency programs and what will be installed through code. Meanwhile, emerging technologies and usage based behavioral initiatives will become increasingly important. The market potential for C&S savings in Figure 73 represents the savings that are forecast to be attributable to IOU C&S advocacy efforts. These savings are technically not EE potential above the baseline, but rather, the estimated savings from Title 20/24 code and federal standard implementation that can be attributed to the IOU C&S program activities. These IOU attributable C&S savings are necessary to quantify in order to set the IOUs goals for the next portfolio cycle, and includes measures that that have shifted from IOU programs into code in recent years, or are planned to shift based on pending code changes.

Figure 73. Incremental Annual Market Potential Impacts 2010–2024 by Measure Type Category



The following factors have played a key role in the changes in energy efficiency potential shown in Figure 72 and Figure 73.

1. **Changes in Underlying Savings Assumptions for Energy Efficiency Measures:** The 2006-2008 evaluation results, as well as several other recent studies, have led to downward adjustments to savings assumptions for many energy efficiency measures. The measure level data used in the 2011 potential study was based largely on the 2006–2008 Energy Division's Evaluation, Measurement and Verification (EM&V) reports. This evaluation cycle reduced the savings estimates for many EE measures. The aggregate results of the 2006-2008 evaluation was an approximate 50% reduction from the ex-ante reported gross and net savings. Prior potential studies were based on measure savings assumptions that were more closely aligned with the ex-ante values. For example, the 2008 potential study was completed before the 2006-2008 EM&V results were available and so the 2008 potential study did not incorporate the majority of the 2006-2008 evaluation data. The 2011 potential study is calibrated to the 2006-2008 EM&V results and so the 2011 potential study is calibrated to measure savings values that are generally lower than the values used in the 2008 potential study and previous studies.

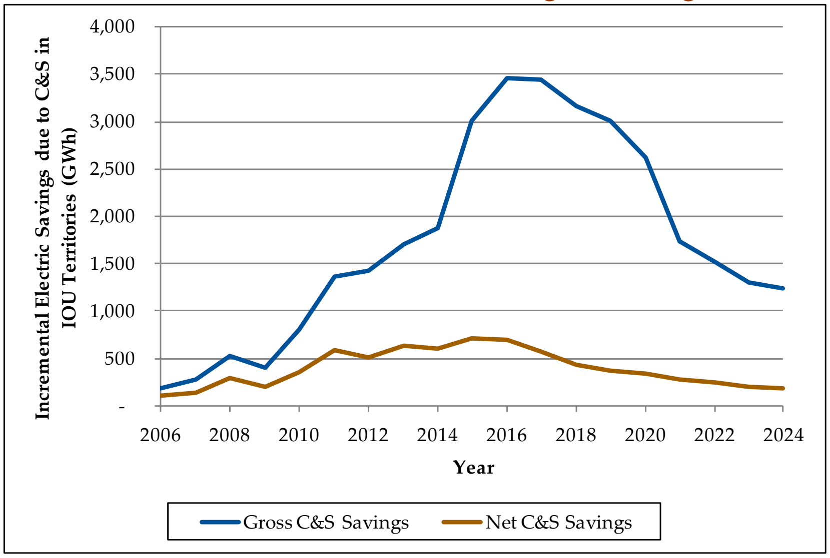
2. **Changes in Codes and Standards:** There have been a number of energy efficiency measures adopted into codes and standards (C&S) since 2008. The California Energy Commission (CEC) most recently updated the state appliance standards (Title 20) in 2011 and building energy efficiency code (Title 24) in 2008. Federal appliance efficiency standards were most recently updated and adopted though legislation and U.S. Department of Energy (DOE) rulemakings, ongoing through 2011. The C&S analysis in this study is based on adopted standards or nearly adopted standards, so the study reflects actual C&S impacts for both CEC and federal standards. The analysis was constrained to codes that have changed since the 2008 potential study and codes that are pending and for which changes in measure baseline can be predicted with some certainty. Additional codes changes will certainly take place over the 2013–2024 time line of this study; however, these "aspirational" codes were not included in this analysis.

   Figure 74 presents the statewide annual gross and net C&S program savings from 2006 to 2024 from all IOUs. Incremental annual gross C&S program savings increase dramatically between 2009 and 2016, but decrease quickly after 2017. The increase is due to active standard adoption of new state and federal standards. Key contributors to quick ramp-up of annual gross C&S program savings include the following:

   - 2008 Title 24
   - 2008 Title 20 Incandescent lamp standards
   - 2009 Title 20 TV standards
   - 2011 Title 20 Battery Charger standards
   - Federal Appliance standards (Most savings are from reflector and fluorescent lamp standards.)

   All appliance standards in the above list have relatively short measure life. High annual savings only last for several years and, therefore, incremental annual gross C&S program savings drop off quickly after 2017. While trends in the gross C&S savings are interesting to observe, incremental net C&S savings are used to inform IOU goals. The annual net C&S savings shown in Figure 74 follows a similar rise and fall trend. However, net savings includes effects of NOMAD and IOU attribution factors, both of which can significantly reduce IOU claimable savings. For example, gross savings for federal standards are significant though only about 6% of federal standard savings can be attributed to IOU programs.

Figure 74. Incremental Annual Gross and Net C&S Program Savings for all IOUs (GWh)



3. **Potential for Emerging Technologies:** Emerging technologies provide new sources of EE potential that were not available when the 2008 potential study was conducted. To assess the potential of emerging technologies, Navigant briefly examined 800 possible emerging technologies and identified and assessed 90 technologies as "high potential." The screening process and subsequent reviews were conducted at a high level because of project schedule constraints, available resources, and inadequate data that often impede the analysis of emerging technologies. This list was ultimately narrowed down to 23 of the highest potential technology types (encompassing 67 individual measures in total) based on several metrics discussed in Section 4.4. These remaining measures were then modeled for this study. Emerging technologies represent a key source of new technical potential, as Figure 3 illustrates.

4. **Potential for Usage-Based Behavioral Impacts:** The 2011 potential study provides estimates of savings potential for residential and commercial behavioral initiatives, which were not included in the 2008 potential study. For this study Navigant broadly characterized the savings resulting from behavior-based initiatives as equipment-based (e.g., replacing light bulbs) and usage-based (e.g., turning lights off) because the persistence and long-term technical potentials of these two types of savings were expected to vary considerably. Equipment-based behavioral impacts are included implicitly in the equipment models of the analysis, as incremental effects to the awareness of measures and willingness to adopt them. Usage-based behavioral impacts are included as additional models.

   While behavior programs have demonstrated significant levels of savings, impact studies have not provided the level of granularity that is necessary for proper representation in a long-term potentials study. The most precisely known impacts from residential behavior programs are of mailed home energy reports, where experimental design and billing analyses are used to identify whole-house impacts during and after program exposure. Average electric savings per participant are typically estimated at around 2% of household consumption. However, this approach provides no insight as to which actions are leading to these savings (equipment vs. usage), and therefore no indication of the expected long-term effects of these programs.

   In the commercial sector, the most rigorous impact estimates are from building operator certification courses, which train building operators on maintenance practices and equipment measures for saving energy. Savings estimates are based on participant interviews and engineering analysis and have typically been 2% to 3% of building energy consumption, with approximately 10% of these savings coming from usage-based actions (i.e., changes to operations and maintenance practices). Much less is known about the impacts of other commercial sector behavior programs.

Furthermore, the potential participation levels in these programs are unclear. Specifically in the residential sector, many customers would be excluded from this potential, such as households on medical rates, households that have recently moved (no basis for feedback), and households withheld from the program to provide a control group for evaluation efforts. Additionally, the persistence of savings beyond a couple of years is unknown, and thus the effective rates of reparticipation are unknown. For commercial programs, it is unknown what percentage of commercial floor space could feasibly be reached by programs each year.

5. **Potential for the Agricultural Market Sector:** The 2011 potential study provides the first estimate of energy efficiency potential for the agricultural sector in the IOU service territories. This estimate was completed in collaboration with the 2010-2012 Statewide Agricultural Market Characterization & Energy Efficiency Potential Study. This model includes limited primary data collected through study and literature reviews conducted by the Navigant team and estimates market potential is generally less than one percent of combined IOU agricultural market sales in any year of the study time frame. Annual incremental market potential in 2013 is estimated at approximately 86 GWh, about 4% of total estimated incremental market potential for that year, with the majority of savings in the process measure category.
6. **Decrease in Forecasted Loads:** The CEC IEPR demand forecast has found a significant decline in the forecasted load from 2008 to 2011 due to the economic downturn. Due to changes in economic conditions since 2008, the 2011 IEPR has forecasted a 5.5% decrease in total consumption. Long term, however, loads are forecasted to increase at about 1.3% per year on average.
7. **Changes in the Modeling Methodology:** The 2008 potential study was developed by Itron using their ASSET model[75]. While Navigant has used a consistent approach, there are variations on certain calculations in the Energy Efficiency Resource Assessment Model (EERAM) model, in particular in the approach to calculating low-income energy efficiency (LIEE) and appliance recycling as discussed in Appendix M.

14.2 Recommendations

While the 2011 potential study provides an update using best available data and accepted methodologies, Navigant has identified several areas that could improve the assessment of market potential, providing a more complete and accurate picture of where the opportunities are to maximize energy savings. The following recommendations are offered with the intention of increasing the comprehensiveness and accuracy of the technical potential provided by this study, and examining market potential may be expanded to more closely approximate economic potential.

14.2.1 Align Cost Benefit Screening with Strategic Plan Objectives

This study and all previous studies use a fairly simple method to screen measures for economic and market potential. Economic potential screens all measures based on a fixed total resource cost test

[75] The ASSET model was developed by Regional Economic Research, Inc. (RER). RER was acquired by Itron in 2003. California Energy Efficiency Potential Study, Submitted to Pacific Gas & Electric Company, Submitted by: Itron, Inc. May 12, 2008

(TRC)[76] threshold, which in this study was set at 0.80[77]. Market potential is estimated based on expectations that a consumer will take action based on a financial incentive, typically a rebate. Using a fixed TRC threshold presents investment criteria that assume all components of a potential study or portfolio present the same risk and reward profile and can be judged with the same metric.

This one-size-fits-all screening approach is inconsistent with the Strategic Plan[78] objective to provide a platform to identify new collaborative initiatives across market sectors and cross-cutting areas, or to help accelerate the improvement of cost-effective EE technologies and program delivery mechanisms over time. This screening approach cannot value these market development initiatives or recognize various nuances, such as, for example, the recognition that technical assistance could yield increased adoption in lieu of rebates in some markets. In order to begin process of differentiating energy efficiency measures such that they can be valued based on their relation to the market Navigant categorized the energy efficiency measures in this study as high impact, secondary, measures on interest, and emerging technologies. These measure categories can also be related to stages of market adoption as defined through the Bass diffusion theory[79]. Subsequent potential study updates may consider this paradigm so that goals, targets, and resulting program interventions can better complement a measure's market adoption phase. For example, the economic screening criteria for emerging technologies could be very different from the criteria used to assess the potential for measures for which code adoption is imminent. This may result in program design intended to more quickly bring new measures to market, while minimizing the cost of promoting mature devices and technologies. Table 40 presents an alternative approach to categorizing measures evaluated in the 2011 potential study using Rogers' technology adoption life-cycle model,[80] including a relationship between the measure category, Bass segment definition, and phase of code development. This might serve as one of several frameworks within which a business case can be developed to more efficiently match resources, markets, and delivery mechanisms for energy efficiency products and services identified in the Strategic Plan.

---

[76] The Total Resource Cost Test (TRC) is defined in the Energy Efficiency Standard Practice Manual, p. 18, which can be found at http://www.energy.ca.gov/greenbuilding/documents/background/07-J_CPUC_STANDARD_PRACTICE_MANUAL.PDF

[77] Similar to the 2008 potential study, the TRC restriction implemented in this analysis was set at 0.85 to reflect the fact that EERAM implements the TRC restriction at the measure level, while the actual cost-effectiveness rule is at the portfolio level. A TRC value less than 1.0 is used to provide flexibility to incentivize measures that are not yet cost-effective and to enable the inclusion of them to install nearly cost-effective measures included in bundled measures like whole-house initiatives.

[78] California Long Term Energy Efficiency Strategic Plan, California Public Utilities Commission, September 2008

[79] Frank Bass, "A new product growth model for consumer durables," 1969, Management Science 15 (5): pp. 215–227.

[80] Rogers' technology adoption life-cycle model assumes adopters of any new technology can be categorized as innovators (2.5% of the population), early adopters (13.5%), early majority (34%), late majority (34%) or laggards (16%), based on a bell curve. Each adopter's willingness and ability to adopt a technology depends on their awareness, interest, evaluation, trial, and adoption. For additional information see: Rogers, E. M., *Diffusion of innovations (5th ed.)*, New York: Free Press, 2003.

Table 40. Relationship between Measure Categories and Market Adoption Phase

2011 Study Measure Category	Related Bass Diffusion Segment Definition	Relationship to Codes and Standards Development	Possible TRC Range
Secondary measures	Laggards	Imminent code (i.e., next code cycle)	1.00
High Impact measures	Late Majority	Near term pending code	0.80 to 1.00
Measures of Interest	Early Majority	Being assessed for code adoption within (e.g., <5 years)	0.70 to 0.80
Measures of Interest and Emerging Technologies	Early Adopters	Possible code adoption Long term (e.g., >5 years)	0.50 to 0.70
Emerging Technologies	Innovators	No current code adoption view	0 to 0.50

14.2.2 Recommendations on Future Research on Select Potential Study Topics

This report was primarily an update to the 2008 potential study, with some additional focus on emerging technologies. As such, it was limited to reviewing and updating select activities but was not able to comprehensively update all existing potential estimates, or address all new sources of potential. For example:

» **Impact of financing on market potential:** This study did not include a review of how financing initiatives might influence market potential. Historically, market potential is based on various incentive levels that are designed to offset some percentage of incremental measure costs, thereby compelling consumers to adopt energy efficiency measures. As adoption rates increase, the difference between economic and market potential narrows. It is recommended that revisions to this study or future potential studies include a methodology to assess how financing influences customer actions and the resulting impact on market potential.

» **Updated market surveys for industrial sectors:** This report provides an update to the estimates of technical, economic, and market potential for the industrial sector by updating some of the parameters used in the 2008 potential study. However the 2011 update did not include a detailed review of measure assumptions because of resource constraints and lack of primary data about various aspects of the industrial market, such as measure saturation.

The availability of current data was not as significant an issue in the commercial and residential sectors because of the 2006 commercial end-use survey,[81] 2010 residential appliance saturation survey,[82] and significant data available on high-impact measures available through the 2006–2008 EM&V project. In contrast, the industrial market is a complex blend of 122 measures installed across various industries as defined by 20 North American Industry Classification System (NAICS) codes. After eliminating redundant applications, this blend of measures and NAICS codes yields a matrix of approximately 1,050 measure applications, many of which are unique within each NAICS market definition. Each measure application has its own set of metrics necessary to inform a potential study, such as useful life, measure savings, and

[81] California Energy Commission (CEC), California Commercial End-Use Survey, CEC-400-2006-005, Prepared by Itron, Inc., March 2006, Final report available at: http://www.energy.ca.gov/ceus/index.html. Data available at: http://capabilities.itron.com/ceusweb/.
[82] California Energy Commission (CEC), California Residential Appliance Saturation Study: CEC-200-2010, Prepared by KEMA-Xenergy, October 2010.

saturation. The 2008 potential study indicated that it is primarily an update to the 2006 potential study. Navigant reviewed the data sources that the 2006 study used to inform its results and found that the study vintages ran from 2004 to 1999, as shown in Table 41. Based on this lineage of updates and sources, the results for the industrial sector in this study are very preliminary and require further work.

Table 41. Study Vintages Used to Inform the 2006 Industrial Sector Potential Estimates

Study Vintage	Number of Studies
2004	4
2003	6
2002	5
2001	8
2000	6
1999	4
1998	3
1997	8
1996	3
1995	1
1994	2
1985	1
Grand Total	51

» **Market survey for agricultural sector**: The estimate of potential developed for the agricultural market lacks the significant field research necessary to develop a robust estimate, similar to the industrial sector. In addition, a detailed potential study of the mining sector has never been undertaken. It is likely that the industrial, mining, or agricultural sectors, which account for 25% of statewide combined IOU electric energy consumption, are fully understood, including the potential for emerging technologies. It is therefore recommended that resources be made available to complete a full potential study on the industrial, agricultural, and mining sectors that include field research on consumers in those markets.

» **Better Align the Potential Study Process with EM&V Activities:** The resource limitations and timing of the 2011 potential study allowed some limited coordination with the 2010 – 2012 EM&V activities, however additional coordination at the EM&V planning and final reporting phases and would improve the accuracy of certain potential model inputs. Navigant identified various model inputs that would benefit from ongoing input and updates from ongoing and planned EM&V activities.

14.3 Next Steps

The following next steps are offered in order to 1) synchronize near term updates to the potential model with industry research that is currently underway, 2) to define key potential study research initiatives that should be addressed in the planning process for the EE portfolio for 2015 and beyond.

1. **Coordinate with 2010-2012 portfolio cycle EM&V activities:** As of the publication of this report there are approximately 50 EM&V studies currently in planning or underway that might be useful in updating the 2011 potential study. Below is a list of 2011 potential model inputs, grouped by five potential study topic groups labeled A thru E. Table 42 provides an initial indication of how these

potential study topic groups might be informed by the 2010-2012 EM&V studies outlined in the 2010-2012 Energy Efficiency Evaluation, Measurement and Verification Work Plan [83]. Refining the relationship between these studies and future revisions to the potential study is an important next steps that should occur as result are finalized from the current EM&V evaluation cycle.

- Potential Study Topic Group A: Measure Impact and Density Metrics
  - » Base Technology Density – The number of baseline technology common measure units within a building type (residential), per 1,000 sq. ft. of building space (non-residential), or per kWh (Industrial).
  - » Efficient Technology Density - The number of efficient technology common measure units within a building type (residential), per 1,000 sq. ft. of building space (non-residential), or per kWh (Industrial).
  - » Total Maximum Density - The total of baseline and efficient technology common measure units within a building type (residential), per 1,000 sq. ft. of building space (non-residential), or per kWh (Industrial).
  - » Modeling Energy Impact (kWh/Unit) – The starting energy input value used in the model. These should be provided as ex ante and ex post.
  - » Modeling Therm Impact (Therm/Unit) – The starting therm input value used in the model at 2013. These should be provided as ex ante and ex post.
  - » Coincident Summer Peak watts/kWh ratio – The ratio of demand to energy used to calculate peak demand potential. These should be provided as ex ante and ex post.
  - » Measure Life – The measure's effective measure life.
  - » Net-to-Gross Factor – A net-to gross value of either 1.0 or a value based on EM&V.
  - » Gas Interactive Effects Applicability – Many measures have effects on other end-uses, such as lighting measures on increased heating load and decreased cooling load.
  - » A/C Interactive Effects Applicability – Many measures have effects on other end-uses, such as lighting measures on increased heating load and decreased cooling load.
  - » A/C Interactive kWh/kWh Effects – For those measures that have cooling load interactive effects, this is the indicator of the amount of the energy interactive effect.
  - » A/C Interactive Watt/kWh Effects – For those measures that have cooling load interactive effects, this is the indicator of the amount of the demand interactive effect.
  - » Heat Interactive Therm/kWh Effects – For those measures that have heating load interactive effects, this is the indicator of the amount of the heating interactive effect.
- Potential Study Topic Group B: Customer Metrics
  - » Technology Awareness – The share of decision makers who are aware of the efficient technology. Value directly input.
  - » Purchase Willingness – Of the decision makers who are aware, the share of decision makers willing to install the efficient technology. Value directly input.

[83] 2010-2012 Energy Efficiency Evaluation, Measurement and Verification Work Plan, Version 1, December 20, 2010 California Public Utilities Commission Energy Division, San Francisco, California

- Payback Sensitive – A yes or no variable that indicates if the measure payback stock participation algorithm is appropriate for the specific measure. Some measures, such as be the Home Energy Report, is not considered to be sensitive to any changes in payback.

- Potential Study Topic Group C: Financial Metrics
  - Avoided Costs by Measure Index – Different avoided cost streams affect measures depending on the end-use affected.
  - Base Incentive ($/unit) – The base year incentive cost per unit. These values are either directly input or are calculated as a % share of measure incremental cost.
  - Technology Cost ($/unit) – The increment or total cost of the efficient technology. The value is incremental if the program is replace on burnout.
  - Administrative Cost ($/unit) – Expressed as a cost per unit and calculated by taking the amount of measure savings and multiplying it against the administrative cost/savings unit that is calculated based on program data.
  - Learning Rate Code – Technology cost for all measures is not considered static in all cases. AN estimate is calculated based on a US Department of Energy paper84, technology costs come down over time at a rate that varies by technology.
  - Number of Years Along the Learning Curve – Related to the learning curve code, measures vary as to where they lie on the curve. This variable is an estimate where a specific measure lies on its learning curve.
  - Discount rate stated as a range or point
  - Program administrative costs by program type
  - Incentive costs based on program tracking data.
- Potential Study Topic Group D: Market Metrics
  - Fuel Share – This value identifies what portion of the building stock has the proper fuel type for the measure. However, for some measures and building types, the fuel share is built into the density values.
  - Applicability - This value identifies the share of the building stock that each measure can be implemented in. For many measures, this value is 100%. Some measures have applicability directly input based on the user's knowledge of the measure and building application. For mutually exclusive measures, applicability will be split in a later step among the competition group measures with the weight being each measures share of individual TRC to the competition group TRC sum. This weighting is re-done each forecast year as TRC values change.
  - Fuel Share and Applicability Adjustment – Some measures are limited in their application by the end-use fuel type they apply to and any limitations to installation that may exist caused by building or appliance characteristics. This value is the multiplication of these two limitations with the form applicability * fuel share
  - Efficiency Competition Group – Some efficiency measures, such as CFLs and LEDs, can be installed to replace the same base technology (in this example incandescent lamps).

[84] U.S. Department of energy (2011). Using the Experience Curve Approach for Appliance Price Forecasting. Supplemental draft paper to the DOE proposed rule in Docket No. EE-2008-BT-STD-0012

Only one or the other can be installed and to prevent double counting, each group of measures considered mutually exclusive are assigned a unique number code.

- » Measure Availability First Year Index – Most measures are considered available for program promotion in the first year (2007) of the forecast. However, some measures are not available until later years (emerging technologies as an example). This variable indicates the first year of availability.
- » Anticipated Impact % Change by end of Forecast – It is anticipated that for some measures the non-codes and standards affected energy impacts will change over the forecast period. An example is refrigerator recycling where the energy impact is expected to decrease significantly by the end of the forecast as newer, more efficient refrigerators enter the population of refrigerators to be recycled. This value shows what percentage of the impact is expected to change over time.

- Potential Study Topic Group E: Sector Topics.

Table 42. 2010-2012 EM&V Studies and Related Potential Model Input Topic Groups

									Energy Consumption, Saturation, Market Share			Market Structure and Decision Making				Sector		
Study Name	Project Number	Measure and Program Impacts	Adoption Effectiveness Assessment	Process Evaluation	Program and Measure Costs	Portfolio Strategy and Management Assessment	Portfolio Impacts	Portfolio Costs	Energy Consumption	Saturation	Market Share	AKA-B Metrics and Measurement	Market Characterization	New/ Enhanced Program Research	Standard Practice Assessment	Res	Commercial	Industrial and Agricultural
Detailed Impact Evaluation of High Impact Measures	1	A																
Impact Evaluation of Custom Measures	2	A																
Impact Evaluation of Strategic Measures	3	A																
Parameter Focused and Cross-Cutting Impact Evaluations	4	A																
Verification and Ex Ante Review/Update Study for Moderate Impact Measures	5	A																
Early EM&V for Non-Residential Custom Projects - ED EM&V Funds	6	A													B,D		A,E	A,E
CFL Laboratory Testing	7	A														A,B,E	A,B,E	
Overarching Process Evaluation of All Residential Programs	8		B	B,D												A,B,E		
ARP Early Feedback Evaluation, Process Evaluation and Market Assessment	10	A	B	B,D	C					B,D	B,D	B,D	B,D		B,D	A,B,E		
Process Evaluation of MFEER and CMHP Programs	13		B	B,D								B,D				A,B,E		
Whole House Process Evaluation and Market Assessment	14	A	B	B,D	C					B,D	B,D	B,D	B,D		B,D	A,B,E		
Moderate Income Direct Install (MIDI) Program Process Evaluation	15	A	B	B,D	C					B,D	B,D	B,D	B,D		B,D	A,B,E		
Overarching Process Evaluation of All Nonresidential Programs	17		B	B,D													B,C,E	B,C,E
Process Evaluation of Sempra's Nonresidential Programs	18			B,D													B,C,E	B,C,E
Process Evaluation of Nonresidential Retrofit Programs	19		B	B,D								B,C	B,C	B,C	B,C		B,C,E	B,C,E
Lighting Programs Process Evaluation and Market Characterization	22	A	B,D	B,D	C					B,D	B,D	B,C	B,C	B,C		A,B,E	B,C,E	
HVAC Programs Process Evaluation and Market Characterization	23	A	B,D	B,D	C							B,C	B,C	B,C	B,C	A,B,E	B,C,E	
Local Government Partnerships Program Process Evaluations	24		B,D	B,D														

Study Name	Project Number	Measure and Program Impacts	Adoption Effectiveness Assessment	Process Evaluation	Program and Measure Costs	Portfolio Strategy and Management Assessment	Portfolio Impacts	Portfolio Costs	Energy Consumption, Saturation, Market Share			Market Structure and Decision Making				Sector		
									Energy Consumption	Saturation	Market Share	AKA-B Metrics and Measurement	Market Characterization	New/ Enhanced Program Research	Standard Practice Assessment	Res	Commercial	Industrial and Agricultural
ME&O Program Process Evaluation	25		**B,D**	**B,D**								**B,C**	**B,C**					
ETP Process Evaluation and Market Assessment	27	**A**	**B,D**	**B,D**								**B,C**	**B,C**					
C&S Market Assessment and Process Evaluation	29	**A**	**B**	**B,D**	**C**					**B,D**	**B,D**		**B,C**		**B,C**			
Early EM&V Research for All Programs	30	**A**	**B**														**B,C,D**	**B,C,D**
Evaluation of PG&E's OPOWER Pilot Program	32	**A**	**B**	**B**												**A,B,E**		
SCE's Enhanced Inspection Study	33			**B**												**A,B,E**	**A,B,E**	**A,B,E**
SCE's Catalina Island Program Improvement Assessment	34		**B**	**B**												**A,B,E**	**A,B,E**	
ACEEE "Big Savers" Best Practices Study	35												**B,C**	**B,C**				
Adoption Effectiveness Assessment	37		**B**													**A,B,E**	**A,B,E**	**A,B,E**
Measure Cost Study	39				**C**													
Measure Cost Study Data Collection Support	40				**C**													
Portfolio Strategy and Management Assessment	41					**C**												
Portfolio Impacts	42						**A**											
Market Effects and Transformation Research	43						**A**											
Portfolio and Program Financial Audit & Analysis	44							**C**										
Macro Consumption Pilot Studies	46								**A**								**B,D,E**	
Residential On-Site/Metering Survey	47									**B,D**						**B,D,E**		
Residential Appliance Saturation Survey (RASS)	48									**B,D**						**B,D,E**		
Industrial Customer Surveys	49									**B,D**								**B,D,E**
Industrial End Use Saturation Study (IEUS, pre 2010-2012)	50									**B,D**								**B,D,E**
Commercial Saturation Survey	51									**B,D**							**B,D,E**	
Residential Market Share Tracking	52										**B,D**					**B,D,E**		
Commercial Market Share Tracking	53										**B,D**						**B,D,E**	
Industrial and Agricultural Market Share Tracking	54										**B,D**							**B,D,E**

									Energy Consumption, Saturation, Market Share			Market Structure and Decision Making				Sector		
Study Name	**Project Number**	**Measure and Program Impacts**	**Adoption Effectiveness Assessment**	**Process Evaluation**	**Program and Measure Costs**	**Portfolio Strategy and Management Assessment**	**Portfolio Impacts**	**Portfolio Costs**	**Energy Consumption**	**Saturation**	**Market Share**	**AKA-B Metrics and Measurement**	**Market Characterization**	**New/ Enhanced Program Research**	**Standard Practice Assessment**	**Res**	**Commercial**	**Industrial and Agricultural**
Overarching Residential Sector Market Assessment	55								A	A,B,D	B,D	D	D	D	D	B,D,E		
Overarching Nonresidential Sector Market Assessment	56								A	A,B,D,E	B,D,E	D	D	D	D		B,D,E	B,D,E
Industrial Sector Market Characterization Study	57								A	A,B,D,E			D					B,D,E
Agricultural Sector Market Characterization	58								A	A,B,D,E			D		D			B,D,E
Building/Facility Renovation/Remodel Rates Study	59												D			B,D,E	B,D,E	B,D,E
Consumer Preference Research to Support Lighting Programs	60											D	D			A,E	A,E	
Measurement and Reporting on AKA-B Metrics	61											D				A,E	A,E	A,E
CEE Energy Star Awareness Survey	62		B									D	D			B,D,E		
Database for Energy Efficiency Resources (DEER)	66																	
Support Ex Ante Development, Review, & Approval (includes non-DEER)	67	A																
Savings Decay and Cumulative Goals Analysis	69	A																
Energy Efficiency Load Forecasting Integration	70	A,C																
Update and Refine Cost-Effectiveness Tools	71	A,C																
T24/T20 and "Reach Codes" Compliance Study	74															A,B,D,E	A,B,D,E	
Strategic Plan Feasibility and Cost-Effectiveness Study	75															B,C,D,E	B,C,D,E	B,C,D,E
Plug Loads Potential Study	76									B,D,E			D			B,D,E	B,D,E	
New Construction Energy Efficiency Potential	77															B,D,E	B,D,E	
Customer Adoption Behavior Study	79											D						

2. **Further refine the potential for emerging technologies:** Because many of measures being implemented by voluntary EE programs will be subsumed by code in the next few years, it will be important to refine the process by which the potential for emerging technologies is assessed and how these technologies are introduced to the EE portfolios such that market adoption can be more fully understood, tracked, and credited. Important next steps to be undertaken in the near term include:
    a. Further refine the definition of what is classified as an emerging technology (ET).
    b. Improve the ET screening criteria discussed in Section 4.4 (and restated in Table 43) to better understand the population of ETs
    c. Assess how cost effectiveness criteria can be applied as these measures mature from pilot initiatives to mainstream, core program offerings.

    Much of the groundwork for understanding the potential for ETs has been established in previous evaluations[85], including specific recommendations on improving the ability to forecast technical and economic potential for the measures.

[85] Final Report: Evaluation of the California Statewide Emerging Technologies Program Prepared by Summit Blue Consulting, LLC, ADM Associates, Inc., California Technology International, Inc., E SOURCE, Energy Market Innovations, Opinion Dynamics Corporation. California Public Utilities Commission Energy Division, February 3, 2010.

Table 43. Illustrative Emerging Technology Scoring Matrix

Technology Assessment Scorecard						
Project Value Components	**Weight**	**1**	**2**	**3**	**4**	**5**
Energy Technical Potential	1	Low		Medium	High	
Energy Market Potential	2	Low		Medium	High	
Market Risk	1	(High Risk) • Requires new/changed business model • Start-up, or small manufacturer • Significant changes to infrastructure • Requires training of contractors Consumer acceptance barriers exist • Long payback (e.g. >10 years)			(Low Risk) • Trained contractors • Established business models • Already in U.S. Market • Manufacturer committed to commercialization • Short payback period e.g. <2 years	
Technical Risk	1	High Risk: Prototype in first field tests	Low volume manufacturer Limited experience	New product (in any market) with broad commercial appeal	Proven technology in different application or different region	Low Risk: Proven technology in target application
Utility Ability to Impact Outcome	1	Private sector will be successful without utility involvement	Utility is unlikely to be critical to adoption	Utility is likely to accelerate adoption	Utility is very important in accelerating adoption	Utility is essential for catalyzing market
Non-energy Benefits*	1	Few or none non-energy benefits	Some modest non-energy benefit likely	Significant benefits, difficult to quantify/ not well understood	1 or 2 quantified, well-documented	Extensive, quantifiable, well-documented

3. **Prioritize research on the potential for behavioral initiatives:** Interest in behavioral initiatives and the increased IOU activity in this area require near term research to more fully assess the potential for these programs. As discussed in 4.5, the following are open research questions that contribute to the near and long-term uncertainty in estimating potentials from both residential and commercial behavior-based programs:

   » What are the specific actions (or action categories, such as usage-based actions, equipment-based actions) that result in impacts from behavior-based programs, and what are the impacts of these actions?

   » What is the action-specific persistence of savings, both in the continued presence of a program and after a participant stops receiving information?

   » What is the overlap in savings between those attributed to a behavior program and those achieved through incentive programs that are not tracked at the site level (e.g., upstream CFL programs)?

   » To what extent are equipment-based savings capturing a new market segment, and to what extent are they accelerating the adoption of equipment that would have occurred in the absence of the behavior program?

   » What are the feasible levels of program participation, and the rates at which programs should ramp up to these levels?

It is recommended that research into these topics begin during the current portfolio cycle as discussed in the Decision Determining Evaluation, Measurement and Verification Processes for 2010 through 2012 Energy Efficiency Portfolios[86].

4. **Develop a scoping plan to more fully assess EE potential for the Industrial, Agricultural, and Mining sectors:** When combined, these sectors account for approximately 24% of total IOU service territory consumption[87] but the potential for EE savings in these sectors is not clearly understood because of the complexity of the sectors and the custom nature of EE projects. It is recommended that a near term scoping study be completed to assess how potential in these sectors can be more accurately assessed, including specific recommendations on study design.

[86] A.08-07-021 et al. ALJ/DMG/avs

[87] California Energy Demand 2012-2022 Staff Preliminary Forecast-Mid Demand Case Electricity Consumption by Sector (GWh). Preliminary CEC IEPR analysis provided to Navigant in June 2011

Appendices

See the "Potential Goals and Targets Study - Track 1 Appendices" files for the following appendices:

Appendix A: Energy Efficiency Potential by IOU and Sector

Appendix B: CFL Data Tables

Appendix C: Behavioral Study Literature Sources

Appendix D: Commercial Building Type Weighting

Appendix E: PG&E Measure-Level Inputs

Appendix F: SCE Measure-Level Inputs

Appendix G: SCG Measure-Level Inputs

Appendix H: SDG&E Measure-Level Inputs

Appendix I: Statewide Industrial Measure-Level Inputs

Appendix J: Agricultural Measure-Level Inputs

Appendix K: Emerging Technologies

Appendix L: Codes and Standards

Appendix M: EERAM Model Algorithm and Input Details

Appendix N – EM&V Coordination Matrix